

FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

EzNav: A mobile Web browser for the elderly

Ana Mafalda Tavares Petiz dos Santos



Mestrado Integrado em Engenharia Informática e Computação

Supervisor: António Miguel Pontes Pimenta Monteiro (PhD)

Second Supervisor: Renato Marcos Guerra de Oliveira (MSc)

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Approved in oral examination by the committee:

Chair: José Manuel de Magalhães Cruz (PhD)

External Examiner: José Maria Amaral Fernandes (PhD)

Supervisor: António Miguel Pontes Pimenta Monteiro (PhD)

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Abstract

Ageing population is increasing around the world and a similar trend is being observed in the population of Internet users. In fact, some studies revealed that people aged 60 years and over constitute the fastest growing group of information seekers on the World Wide Web. However, inadequate interface designs of existing technology tools and apps constitute a barrier to elders' digital inclusion. Besides, most older adults suffer from a decline in their visual, motor and cognitive skills that may hamper Web interaction.

The project described in this document aimed at the development of an Android mobile application that consists of a Web browser for older adults, focusing on their needs. This was done through an in-depth literature review on older adults' characteristics and behaviours towards Web interaction, as well as on guidelines for designing for older people, in order to find possible modifications and improvements regarding elder users' interaction with current technologies. The application was implemented as a proof of concept and it aims at being senior-oriented, not only by considering graphical user interface (GUI) aspects (like using fewer, bigger buttons), but also Web engine aspects (removing ads, increasing spacing between paragraphs, changing colours, and enlarging images).

In order to validate the solution and get feedback from users, both low- and high-fidelity prototypes were developed and tested with a group of elders, at a social centre. This allowed for a fast-paced cycle of continuous development and testing, thus increasing the received feedback and, consequently, the overall quality of the system. Given these premises, the development of this project followed a user-centred design (UCD) methodology, which puts the user at the centre of the design process.

The results from the final usability tests proved promising, with all test participants performing all tasks, with no effort. Besides, seniors, in general, felt the application was easy to use and all of them would like to use it again, which shows great acceptance and interest in the application. Given these results, one can say that all the goals were, in general, fulfilled.

Resumo

A população mundial está a envelhecer, podendo-se observar uma tendência semelhante no que diz respeito aos utilizadores da Internet. De facto, estudos revelam que as pessoas com mais de 60 anos constituem o grupo com maior crescimento, no que concerne à procura de informação na *World Wide Web*. No entanto, os desenhos ineficientes das ferramentas tecnológicas e aplicações existentes constituem uma barreira à inclusão digital, por parte dos idosos. Além disso, a maioria destes sofre de um declínio nas suas capacidades visuais, motoras e cognitivas, o que poderá dificultar a interação Web.

O projeto descrito neste documento tem como objetivo o desenvolvimento de uma aplicação Android, que consiste num navegador Web para os seniores, tendo como foco as suas necessidades. Para tal, foi feita uma revisão da literatura em profundidade acerca das características e dos comportamentos dos adultos mais velhos em relação à interação Web, para que fosse possível encontrar modificações e melhorias a fazer, no que toca à interação de utilizadores idosos com as tecnologias atuais. A aplicação foi implementada como uma prova de conceito e visa ser orientada para os seniores, não só por considerar aspetos gráficos da interface (tais como usar menos botões e maiores), mas também aspetos do motor de navegação da Web (como remover anúncios, aumentar espaçamento entre parágrafos, alterar cores e aumentar imagens).

De modo a validar a solução e a obter *feedback* dos utilizadores, protótipos de baixa e de alta fidelidade foram desenvolvidos e testados com um grupo de idosos, num Centro Social. Isto permitiu um ciclo acelerado de contínuo desenvolvimento e testes, aumentando, assim, o *feedback* recebido e, consequentemente, a qualidade geral do sistema. Tendo em conta estas premissas, o desenvolvimento deste projeto seguiu uma metodologia de desenho centrado no utilizador (*user-centred design*), que, como o nome indica, coloca o utilizador no centro do processo de desenho.

Os resultados dos testes finais são promissores, na medida em que todos os utilizadores foram capazes de realizar todas as tarefas, sem dificuldades. Além disso, os idosos, em geral, consideraram a aplicação fácil de usar e todos eles mostraram interesse em utilizá-la novamente, o que reflete uma grande aceitação da mesma. Tendo em conta estes resultados, pode-se afirmar que os objetivos estabelecidos foram, de modo geral, cumpridos.

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None of this would have been possible without the help of a lot of people, who always believed in me and always supported me.

First of all, I want to thank my parents, without whom none would have happened, either for the monetary support and for all the opportunities they granted me, or for always believing in me and fighting for me every single day of their lives; for making me want to always be more and better and joining me in this long, and sometimes stressful, journey; for instilling me values like integrity, humility, honesty, commitment and respect; for recognizing my effort; for always being available to help and assist in what they can... Ultimately, for all the love and, simply, for existing.

Also, I could not help to thank my older brothers, who have always protected me, for being my reference and an example to follow, and for completing my life. There are no words that can describe the link between us.

In short, I thank all my family as they are the best that one can have in life and were a great foundation for me to become the person I am today. Because when everything else fails, they are always there for me.

I want to particularly thank my aunt, for reminding me that we cannot take anything for granted and that we must learn to appreciate what we have and while we have it; for having an unrivalled strength, even without knowing it; for making me grow up and become a better person; for showing me that, even when everything seems to be collapsing, there is always a reason, however small it may be, that give us the strength to move forward. In other words, for being the perfect aunt, because like they say, "Only an aunt can give hugs like a mother, keep secrets like a sister and share love like a friend".

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Ana Santos

“carpe diem, quam minimum credula postero”

Horace’s Odes

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Abbreviations

API	Application Programming Interface
CSS	Cascading Style Sheets
DOM	Document Object Model
FAQ	Frequently Asked Questions
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HD	High-Definition
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IPS	In-Plane Switching
JS	JavaScript
OS	Operating System
PC	Personal Computer
PDA	Personal Digital Assistant
SDK	Software Development Kit
UCD	User-Centred Design
UI	User Interface
URL	Uniform Resource Locator
W3C	World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines
WQXGA	Wide Quad Extended Graphics Array
XML	Extensible Markup Language

Chapter 1

Introduction

This document aims at reporting the insights and knowledge acquired about the master thesis "EzNav: A mobile Web browser for the elderly".

This chapter describes the context in which this project falls, followed by the problem associated with it, as well as the goals and expected benefits of the proposed solution. In addition, a brief description of the next chapters is made.

1.1 Context

According to the United Nations, ageing population is increasing around the world, and will continue to do so for the next decades: it is expected that by 2025 there will be around 1.2 billion over-60 people, reaching approximately 2 billion by 2050. Consequently, the number of older adults that use the Web to enhance their independent participation in society will increase [PK12].

In fact, people aged 60 years and over constitute the fastest growing group of information seekers on the World Wide Web [HL02].

However, inadequate interface designs of existing technology tools and apps constitute a barrier to elders' digital inclusion. So, it is important to fight this, by finding an effective way to involve the elderly on the development process and by giving some examples of appropriate technologies [DNSH05].

Some authors state that the regular use of Internet may help to reduce isolation, loneliness and depression rates in older adults, thus improving their quality of life [OYC11, WMC⁺99, WMC⁺02, dMF09, SGTK12].

Furthermore, the emergence of the Internet has intensified the process of digital exclusion, i.e., those who do not often use the computer (in general limited by financial or ageing conditions) have no access to facilities and communities in the virtual world [dMF09].

With that said, it is essential that older adults (like everyone else) can have proper access to Web resources, in order to take advantage of their vast benefits.

The project detailed in the present document was developed in Fraunhofer Portugal facilities, as a module of an existing suite of apps for older adults known as Smart Companion and Go-LivePhone, with the goal of providing a simple and intuitive Web browser for elder people, thus facilitating Web interaction for this type of users.

The above-mentioned project consists of a set of applications for Android smartphones that were specially designed to meet older adults' needs. This service was designed by Fraunhofer Portugal, aiming at a social ecosystem where seniors, caregivers and service providers interact with each other, providing a permanently available companion to help and support users, especially seniors, in their daily actions. To achieve this, the application follows user-centred design (UCD), a methodology that puts the user at the centre of the design process, in order to have an appropriate design to seniors' needs.

1.2 Problem

As people get older, some difficulties arise, such as vision, cognitive and motor impairments, that may be an obstacle for Web interaction [SnnK06]. Besides ageing-related functional impairments, older people tend to be reticent about using the Web also because they have some fears, which include: damaging the machine, erroneously deleting files, providing personal data, privacy invasion, installing some kind of malware and not knowing what to do in a given situation. These fears arise from these user group's own lack of knowledge, discouragement and, often, lack of family support [TB10].

1.3 Objectives

The work in this thesis aims at developing a mobile application, as a proof of concept, that consists of a Web browser for older adults, focusing on their needs. To achieve this goal, work was divided in two phases: knowledge acquisition and development.

In the first phase of this project, several studies and analysis on Web interaction were held to find possible modifications and improvements regarding senior user interaction with current technologies. The developed application should be senior-oriented, not only by considering graphical user interface (GUI) aspects (like using fewer, bigger buttons), but also Web engine aspects (like removing ads, increasing spacing between paragraphs, changing colours, and enlarging images).

Then, in the second phase, in order to validate this solution and get feedback from users, a prototype was developed and validated with a group of elders, so further improvements could be done, if needed. Doing this was important to create a fast-paced cycle of continuous development and testing, thus increasing the received feedback and, consequently, the overall quality of the system. Given these premises, the development of this project followed a UCD approach.

1.4 Expected benefits

According to some authors [WMC⁺99, dMF09], for the elderly, the Internet is considered a form of entertainment and an important tool for preventing social isolation [WMC⁺02], loneliness [SGTK12] and depression rates in older adults, especially because it promotes interaction and social life, overcoming limiting barriers such as physical disabilities [OYC11]. That way, the Internet can help seniors to maintain their independence, thus contributing to their general well-being and, consequently, improving their quality of life. This is probably one of the reasons why Internet use by older adults increased in the past few years [SnnK06].

With this work, it is hoped that the elderly learn to confidently and easily surf the Web, and consequently realize its vast benefits, namely fighting loneliness, keeping their minds "busy" and staying in touch with family and friends, thus promoting active, independent ageing and bringing happiness to older people.

1.5 Document structure

This document is organized in 7 chapters. This first chapter contains an introduction to this work and outlines the problem addressed in this thesis, as well as the context in which it is inserted and the motivation and contributions expected with this work.

Chapter 2 consists of the state of the art review, which includes some studies about elderly's behaviours, as well as an analysis of similar products. In chapter 3 there is a brief description of the methodologies followed in the development of this project, as well as the reasons for choosing those methodologies. Chapter 4 describes the design process of the application, which includes the data gathering, the requirements specification and the initial usability testing. Then, the project implementation is detailed in chapter 5, followed by the working prototype evaluation, in chapter 6. Finally, in chapter 7, the document is concluded with an overview of the status of the system, main conclusions and achievements as well as future work possibilities.

Introduction

Chapter 2

State of the Art

In this chapter, a review and analysis of the state of the art is made. It includes an analysis of the target users, as well as design guidelines for these users and an analysis of existing technologies and similar products.

2.1 Elderly's interests and fears, while using the Web

Older adults have three kinds of interests while learning to use the Internet: social, professional and familiar. Social interest relates to the possibility of digital inclusion. The professional interest concerns the independence in routine works or even in some extra work that the elderly can get involved with. With regards to family, the interest resides in following the younger members and facilitating communication with them. Online games also generate interest, as a means of fun [TB10].

Among all these factors, the most frequent reason for using the Internet is to keep in touch with family, relatives and friends. Accessing news and research on health topics is also frequent, which makes search engines the most favourite websites [SnnK06]. On the other hand, generally older persons are reticent about using the Web, because they have some fears, which include: damaging the computer, erroneously deleting files, providing personal data, privacy invasion, installing some kind of malware and not knowing what to do in a given situation. These fears arise from their own lack of knowledge, discouragement and, often, lack of family support [TB10].

2.2 Ageing-related functional impairments and their implications for Web interaction

The obstacles faced when using the Internet are due to several limitations that inevitably arise with ageing. Since the Web generally follows a visual interaction paradigm, vision problems are the

biggest issue in Web interaction. However, cognitive and motor impairments also prevent older people from interacting with the Web effectively and efficiently [SnnK06, DAP07].

2.2.1 Visual age-related changes

In respect to visual impairments, there can be several types of physical changes in the eye, requiring some adjustments in the way content is displayed [KKEB06, Web09]:

- Generally failing vision, requiring the information to be presented in a larger size. Empirically derived guidelines suggest using 12- or 14-point font size for older adults with normal decline in their vision.
- Corneal flattening, which reduces the amount of light passing through the eyes. This necessitates the information/background contrast to be maximized in critical areas.
- Feeling of "tired eyes", caused by the reduction of focusing power due to the loss of the tension of the ciliary muscles and lens elasticity. The eyestrain is compounded by the use of capital and emboldened letters, and also by using several types of fonts mixed together or very narrow or decorative fonts, since it does not give the eye sufficient rest. Bright and vibrant colours are also harmful, because they create after-images, tiring the eyes. Eye fatigue can be attenuated through an effective use of white spaces and by presenting text in small blocks.
- Yellowing of crystalline lens, which means that less violet light is captured by the eye, making it easier to see reds, oranges and yellows and more difficult to see blues, greens and violets. This problem can be solved by presenting information in the colours that are easier to see and using the other ones as background.
- Visual field reduction, resulting in reduced peripheral vision, requiring that important information is presented as close to the centre of the screen as possible. However, this is not an easy task because screen objects need to be larger to ease general failing vision.
- Retinal efficiency reduction, leading to a decreased capability to adapt to glare or to changing light conditions. This means that negative polarity (light coloured text on dark coloured background) is probably more readable than a positive polarity setup in certain lighting conditions.

2.2.2 Motor age-related changes

Mouse and keyboard are still very used for Web interaction. Nonetheless, due to ageing-related motor impairments, using a mouse can be a big challenge to the elderly. Such motor impairments include the following [KKEB06, Web09]:

- Arthritis, which makes it very difficult to coordinate some movements. For instance, "click and drag" and scrolling are extremely difficult for some older people. One possible solution

for the latter is to break pages with worthy information into pieces of no more than one or two screens.

- Reduced capacity to do repetitive fast movement, like double-clicking. A possible solution to this problem is Microsoft's single-clicking option or changeable double-clicking speed.
- Another possible solution for both these problems is to use a touchscreen device, since it does not require as much physical interaction as using a mouse and interactions tend to be more natural.

2.2.3 Cognitive age-related changes

Cognitive skills are needed while surfing the Web, such as recalling, reasoning, recognition, skill acquisition and comprehension. Ageing research indicates that older adults have poor performance in almost all of these skills, due to cognitive impairments, such as the following ones [KKEB06, Web09]:

- Decreased capacity to learn and retain new information. Providing a simplified tutorial, with tasks broken into subtasks, may help. Also, reminders and frequently asked questions (FAQs), as well as context-sensitive help, are useful to assist recall.
- Reduced spatial and visual information processing, leading to difficulty in finding a target in a complex webpage. Reading a map is somewhat difficult for them, so providing written directions to get to a place is a better approach. Also, presenting information on one- or two-dimensional form is more favourable for the elderly's understanding.
- Lower cognitive processing speed calls for control over time-sensitive content changes in Web interaction, like slowing down or even stop walking banners and flashing text. The avoidance of walking and blinking objects also helps the elderly to not get so easily distracted, thus improving the cognitive process.

2.2.4 Behavioural characteristics

Besides physical impairments, there are some behavioural characteristics that prevent seniors to take full advantage of Web functionalities, such as increased cautiousness (they hesitate on giving responses that might be wrong) and low confidence on their ability to use technologies, including the Web, due to the fact that some older people have never used this (or any other) kind of technology. Introducing the technology in a highly interactive and understandable manner may positively influence the receptivity of older adults toward technological devices [KKEB06].

Moreover, a study conducted by Sa-nga-ngam and Kurniawan [SnnK06] allowed to identify some problems that older users faced while using a Web browser, which can be divided into six categories: undesired content (advertisements, pop-up windows, spam), connection (slow connection, security concern), broken links (404 error message), poorly designed pages, compatibility

(some websites only work with specific Web browsers) and undesired actions (such as pages that refuse to close).

There are a number of existing technologies that can help the elderly to overcome barriers to Web access, including: user device solutions (large computer monitors or special input devices), user software solutions (for example, font size and colour changes through browser settings) and Web author solutions (such as the Web accessibility initiative from the World Wide Web Consortium, W3C). The problem with these solutions is that individual users need to be aware of the device and software advances/changes, and they also need to make the necessary changes to fit their needs. Keeping track of technological advances is a very difficult task for everyone, let alone older adults, that are unfamiliar with the multiplicity of technologies. Besides, current solutions only solve specific and individual impairments [Han01].

Researchers argue that a profile-based solution for accessibility, where the final rendering is adjusted according to the user preferences, is ideal [Sto08].

2.2.5 Touchscreen devices: a possible solution

In order to mitigate the difficulties faced by elder adults, the use of touchscreen devices should be considered, since touch-based interfaces are easier to use and understand for people who are not very familiar with computer technologies [SSI⁺98].

Touchscreen devices benefit from the fact that the input and output device are the same. That way, users are able to touch and directly interact with objects on the screen, which provides them a sense of immersion, improving their experience. For this reason, this is considered one of the most natural technologies. Besides, since it does not need any added accessories, such as keyboard or mouse, it saves working space [Hol03].

Existing studies give support to this idea, showing that touch-based interfaces are an intuitive and natural way to interact with a device, facilitating human-computer interaction for the elderly. Moreover, this kind of interfaces require less learning time and less computer literacy and, at the same time, lead to a high degree of user satisfaction [LR11, MI05]. The results of one of the studies also indicate that touch-based interfaces should be aggressively pursued, in order to make information technologies accessible to older people [MI05].

However, the disabilities faced with ageing make it difficult to use the fingers to accurately point to small areas on the screen, since buttons on a smartphone, for instance, are too small. This problem can be easily bypassed, given that button size and arrangement are under software control [Sto08].

Another way to solve this problem may go through giving preference to the use of tablets. In fact, results of a study on usability and acceptance of a selected tablet, conducted with 11 seniors with no previous Internet or computer experience, indicate that tablets are an easy way for older people to step into the digital world. Thus, the authors argue that future focus should be given to the development of tablet-based applications for older adults [WWO12].

2.3 Web design guidelines for older people

Several studies have been made about designing Web applications for older users. Many research papers in this scope reference the guidelines developed by [KZ05]: a set of 38 design guidelines, grouped under 11 category headings, suitable for Web applications targeting older adults.

The authors developed this set of guidelines through extensive literature review and then conducted heuristic evaluation to validate them. These guidelines are very detailed and comprehensive and cover the main areas of ageing-related functional impairments that may prevent the elderly to benefit from Web interaction.

These are the 11 category headings: target design, use of graphics, navigation, browser window features, content layout design, links, user cognitive design, use of colour and background, text design, search engine and user feedback and support. Each of the 38 guidelines, with detailed descriptions, can be found in Appendix A.

2.4 Technologies

This section contains a brief description about the technologies that can be used in the development of this project.

2.4.1 Web technologies

Since the application being developed consists of a Web browser, the use of Web technologies is imperative.

2.4.1.1 HTML

HyperText Markup Language (HTML) is the standard markup language used for creating and visually representing a Web document, describing its structure and semantic content [Net15a, W3s15a].

HyperText is text that contains links to other texts. Through this method, one can navigate on the Web, by clicking on hyperlinks that lead to another page. Markup defines how text within the HTML tags should behave, by marking it as a certain type of text (e.g., bold text) [Sha15].

Web browsers can then read and interpret these HTML markup files, by rendering them into a tree structure (Document Object Model) using built-in engines (such as Gecko, used in Mozilla Firefox, Webkit, used in Google Chrome and Opera, or Trident, used in Internet Explorer). This structure is then used to display the website in a user-friendly way - the webpage as we see it [Chr15, O'C15, Msd15].

2.4.1.2 CSS

Cascading Style Sheets (CSS) defines how HTML elements should be displayed, by adding styles (e.g., layout, colours, fonts, spacing) to Web documents, and it allows adaptation to different devices [W3.15].

Since CSS follows the principle of separating structure/content from presentation (the CSS is independent from the HTML), it is possible to share style sheets across pages, and reuse CSS for multiple pages, which makes the maintenance of the websites much easier [W3.14].

2.4.1.3 DOM

The Document Object Model (DOM) is a cross-platform and language-independent convention for representing Extensible Markup Language (XML)-like documents (e.g. XML, HTML). This convention consists in loading and parsing the different document elements, as well as its attributes, to a tree structure, called the DOM tree. A browser uses DOM trees as an intermediate representation between the markup code of an HTML document and the graphical visualization that is rendered on the screen. DOM trees allow their elements to be addressed and manipulated through an Application Programming Interface (API), which together with a client-side language such as JavaScript, can be used to create client-side dynamic pages [W3.09].

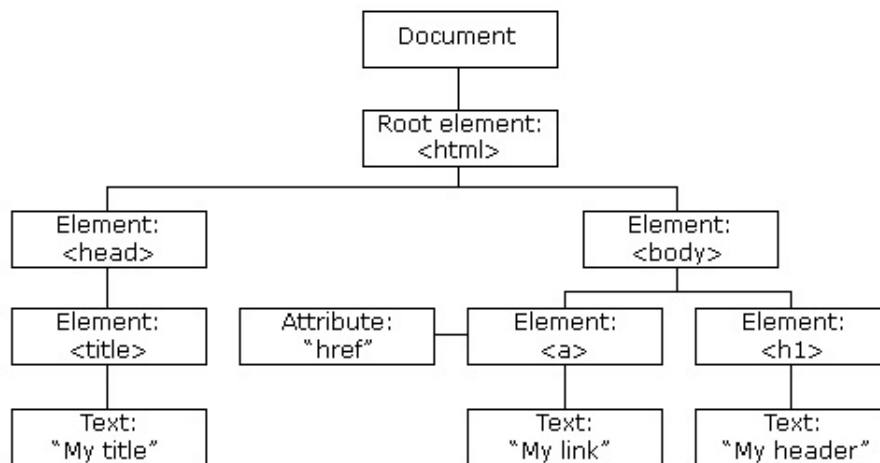


Figure 2.1: The HTML DOM tree of objects [W3s15b]

2.4.1.4 JS

JavaScript (JS) is the most popular programming language in the world [W3s15c]. It is an interpreted, lightweight language mostly known for being the standard scripting language for building webpages. While this may have once been true, its prototype-based, multi-paradigm characteristics (which allows dynamic, object-oriented, imperative and functional programming styles),

have seen its usage expand to non-browser environments such as Node.js and Apache CouchDB [Net15b].

2.4.2 Android

The increase in the use of mobile systems like mobile phones and Personal Digital Assistants (PDAs), led to the development of smaller, more versatile operating systems, capable of running applications in a touchscreen environment. Based on Linux, Android is a low-cost, customizable and lightweight open-source mobile operating system widely used by almost every mobile phone manufacturer, leading the smartphone market with 283 million units shipped, totalling 84% of the share (data from jul-sep 2014) [sit15, www15].

Due to Android's development tools (Android Software Development Kit (SDK), Android Studio, Integrated Development Environment tools) being freely available to major operating systems (Windows, Linux and Mac OS) and the ease in developing new applications, the number of applications available is growing exponentially [Cas15].

2.4.2.1 WebView

WebView is an extension of Android's View class, which is the base class for creating interface components, being responsible for handling drawings and events.

The WebView is specifically used to deliver a webpage (or even a Web application) as part of a client application. With it, webpages can be displayed as a part of the layout. By default, WebView only shows a webpage, not containing any elements of a totally developed browser, like an address bar or navigation buttons [Web15].

Although security flaws have been found in WebView, such as injecting malicious JS code to gain command-shell access to the device, this issues will only affect Android versions before Android 4.4 KitKat [Smi15, Rea15].

2.4.2.2 SQLite

SQLite is an open source database that supports all the relational database features. Android devices come in with a built-in SQLite implementation. One of the advantages of this technology is that it does not require any database setup or administration. Besides, since it requires low memory runtime (approx. 250 Kbyte), it is suitable to be embedded into another runtimes [Vog15].

2.5 Methods for webpage's personalisation

Despite the fact that many content presentation problems can be solved at the design stage, personalising webpage presentation can be really beneficial to those who find the Web a "daunting place". There are a number of instruments that allow a webpage to be personalised so it can satisfy the individual needs of older users. In this section, some of them are presented.

2.5.1 Accessibility features of standard browsers

Standard Web browsers can provide a first step of dealing with older adults' functional disabilities, if HTML designers follow the principle of separation of content and presentation. These browsers allow users to select colour schemes or font sizes and types that suit them, overriding the design defined by the HTML codes [KKEB06].

The problem with this approach is the need to configure the browser, which may be difficult for inexperienced users, especially the more complex changes, such as customising a CSS file to match one's preference. Furthermore, in some cases, the changes made might alter the information layout or not have any effect on the presentation [KKEB06].

2.5.2 Assistive technology

Assistive technology can be defined as "any item, piece of equipment, or system, whether acquired commercially, modified, or customised, that is commonly used to increase, maintain, or improve functional capabilities of individuals with disabilities" [KKEB06].

Using this technology on top of a standard Web browser has distinct advantages, such as support for all websites, full range of functionality and little need for configuration. Besides, individuals feel reassured, since they can use the same software as colleagues and friends, having access to the same content. Finally, support to problems related to the browser is easy to find [KKEB06].

Users can simply install the required system to meet their needs, for example, a screen magnifier to enlarge content and ease readability or a voice recognition system to overcome motor difficulties.

2.5.3 Personalisation's trade-offs

One important trade-off of the personalization instrument is that it demands a place on the developer and on the end user, which includes the support and intervention requirements and the extent to which the user must be in control of setting, installing and understanding how the personalised page works [KKEB06].

The powerfulness of the instrument is influenced by the demands made on users or expectations about it: the higher they are, the more powerful it can become. This, however, means that, in order for it to be adopted, there will be more obstacles to overcome, such as users being unable to install software or being reticent (or even unable) to set apart from their already known solutions and configurations [KKEB06]. Indeed, several studies suggest that elderly users are not willing to perform personalisation by themselves, due to lack of confidence [SnnK06]. Given this, working on default and omnipresent browsers may be a better approach.

A second trade-off concerns the relation between faithful representation of original content and layout and users' impairments. In most cases, preference is given to instruments that facilitate page reading and navigation, and, simultaneously, preserve the original layout and content. However, for users with severe impairments, simplified and alternative presentation may be more eligible,

since they probably have no choice but to rely on magnified and read-out information provided by the instruments [KKEB06].

2.6 Usability of Web interfaces

Work has been done in order to identify and list the accessibility indicators that target the elders. The Web Content Accessibility Guidelines (WCAG) document, from the World Wide Web Consortium (W3C), provides some guidelines that help raise the profile on Web accessibility. However, these guidelines still lack design recommendations and solutions that address older adults' needs [AWdSF10].

Indeed, design guidelines and recommendations are not enough when dealing with elderly's needs. For these users, usability issues go beyond making a system easy to use: they must learn how to use it and, at the same time, learn what the system can do [CGPBL⁺13]. Results of a study indicate that the mental model of elder users can be successfully represented in Web applications, but doing so requires an additional effort in designing and evaluating such applications [CGPBL⁺13].

Human-computer communication with older people may benefit from the use of icons, because icons can be easily recognized and remembered, since pictures provide a universal recognition. Besides, icons provide user references/calls to action (affordance), providing a more intuitive use of the technology [MBP⁺12].

2.6.1 Usability and accessibility of Web interfaces

Usability and accessibility have been increasingly studied and exploited, when developing Web interfaces. The usability concept is usually related to five attributes, that may be taken as a set of separate quality attributes or as a single attribute comprising all of them: learnability, efficiency, ease of storage, low error rate and user satisfaction [AWdSF10].

Nielsen [Nei00] provides some basic principles that should be considered in the development of Web applications:

- Clarity in information architecture: users should be able to identify what is priority and what is secondary in a website.
- Ease of navigation: user should not need more than three clicks to access the desired information.
- Simplicity: the website structure should be simple, so that its content can be easily understood and information can be deleted without compromising the whole system integrity.
- Content Relevance: the focus of a website design should be on the content of information provided. Also, presentation should be consistent within different webpages, in order to improve the learnability of the application, thus providing the user a sense of confidence while operating the website.

- Time bearable: it is imperative that the load times of pages are short, in order to prevent users from losing interest.

On the other hand, accessibility can have different meanings, depending on the context in which users operate. In the Web context, accessibility means the ability for any user, using any kind of agent (a piece of software or hardware that retrieves and serializes Web content to a human-readable format), to understand and interact with website contents [AWdSF10].

Literature is not clear about the relationship degree between usability and accessibility, but some authors [PK07] argue that both concepts should be combined into a "universal usability", in order to reduce the existing gap between usability principles and accessibility guidelines.

2.7 Similar products

In this section, some products related to this work will be presented and briefly described. This description is done by gathering information publicly available on their websites and, in some cases, by checking reviews made by other users. Also, when possible, the application was downloaded and installed to check its functionalities.

2.7.1 Eldy

Eldy [Eld15] is a software that turns any standard personal computer (PC) into an easy-to-use computer for people that have never used such machine before. It is also available for Android tablets.

Its interface was specifically designed to meet the needs of older adults, with each menu box choice being very easy to click on as a target element. The boxes use icons and large font sizes that are easy to read. The text is presented with a dark blue colour on a light blue background for easy contrast differentiation, which improves the readability of menu boxes.

Figure 2.2 shows "The Square", Eldy's main screen interface.

From the square one can:

- send e-mail ("mail");
- browse the Internet ("walk in internet");
- create and edit a profile ("my profile");
- chat with friends, relatives or other users online ("chat");
- watch videos ("eldy tv");
- write documents, watch pictures, know the weather forecast and use Skype ("useful");
- have access to the "help" area where one can change the settings and play easy games.



Figure 2.2: Eldy main screen [Eld15]

2.7.2 intuNET

intuNET [Int], from Intutula, is an Internet application for PC designed for senior people, to help them overcome physical and cognitive difficulties.

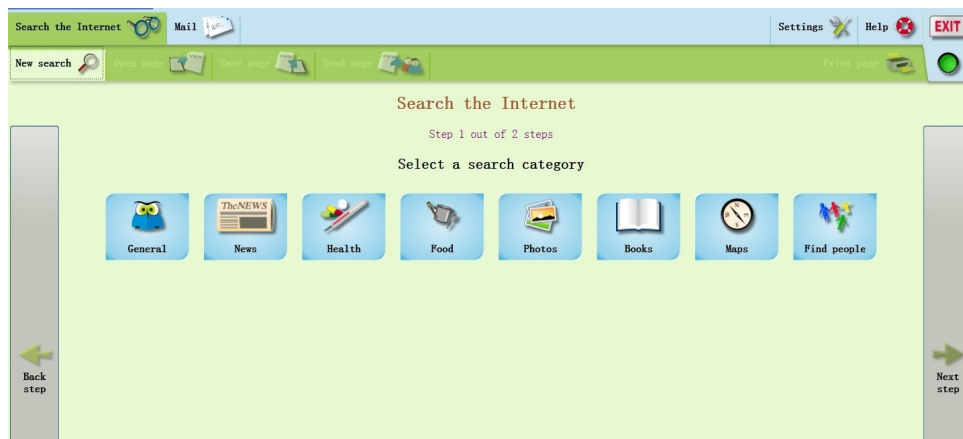


Figure 2.3: intuNET Web browser [Int]

intuNET's main features are a Web browser and e-mail services. According to their website, "intuNET is taking a completely new approach to the user interface (UI) and user interaction process so that age-related difficulties are no longer a barrier:

- Simple clean interface with a few large buttons and large text to handle most needed operations.
- Native-language instructions - no need to speak computer jargon.

- Guided step-by-step instructions prevent the need to remember how to execute complex procedures.
- Simple mouse operation - single-click, left-button-only, no dragging required. Simplified, clutter-free Internet search and browsing.
- Easy to use Email.
- An excellent application for grandparents or parents."

Figure 2.3 shows intuNET's browser interface.

2.7.3 Phonotto & Wiser

Phonotto [Pho15] and Wiser [Wm15] are two different Android launchers, although very similar, in the sense that they are both designed for seniors, replacing the regular home screen with one specifically tailored for this type of users.

The Phonotto home screen has three quick-dial buttons which can be set to any phone number one desires very easily. It also includes four very big, colourful buttons for calls (dialler/contacts), messages, photos and applications. Each of these buttons takes the user to dedicated designed screens, instead of just leading to the phone's regular screens.

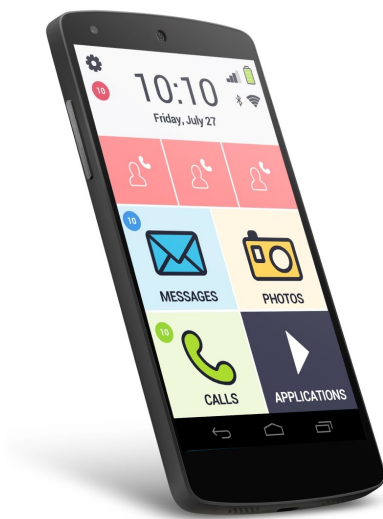


Figure 2.4: Phonotto main screen [Pho15]

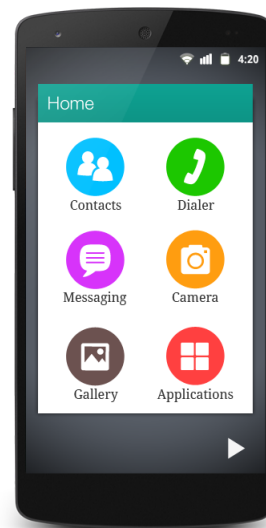


Figure 2.5: Wiser main screen [Wm15]

On the other hand, Wiser's home screen also has big and colourful buttons for contacts, dialler, messaging, camera, gallery and other applications. In this case, however, only the first two buttons lead to specially designed screens; the other ones just take the user to the default Android screens.

Although both these applications are senior friendly, they both lack a dedicated module for Web browsing, only allowing to add a default browser to "Applications".

These launchers' main interfaces can be compared, observing figures 2.4 and 2.5.

2.7.4 Hakisa

Hakisa [Hak15] is another PC and mobile application designed for senior adults. According to their website, with Hakisa one can:

- Communicate with one's relatives ("My Relatives");
- Visit one's favourite websites in one click ("My Internet");
- Share one's passions in clubs ("My Clubs");
- Buy online easily and securely ("My Services");
- Manage and share one's events ("My Agenda");
- Play one's favourite games online ("My Games");
- Help or request help ("My Help").

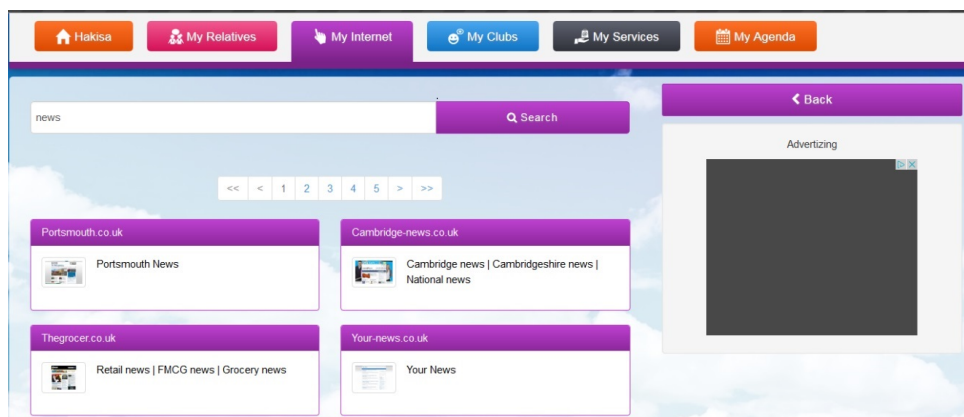


Figure 2.6: Hakisa Web browser [Hak15]

Although the complete solution is helpful and interesting, there is a problem that can be identified in the Internet module - search can only be done based on a pre-defined set of keywords, like "news". By typing in a Uniform Resource Locator (URL) or a keyword not included in their keyword's set, the search will not return any results. An example of using Hakisa is shown in Figure 2.6.

2.7.5 iN-TOUCH

iN-TOUCH [Sen15b] is a 10-inch tablet, designed for seniors, that provides simple one-touch, big-button access to the Web, email, text messaging, calendar, video chat, medication reminders and more.

As of the time of this writing, one can only test the interface on the site's page. The Web browser functionality has a simplistic design, and search can be done by categories, as shown in Figure 2.7. The "Search" button redirects to Google's homepage.

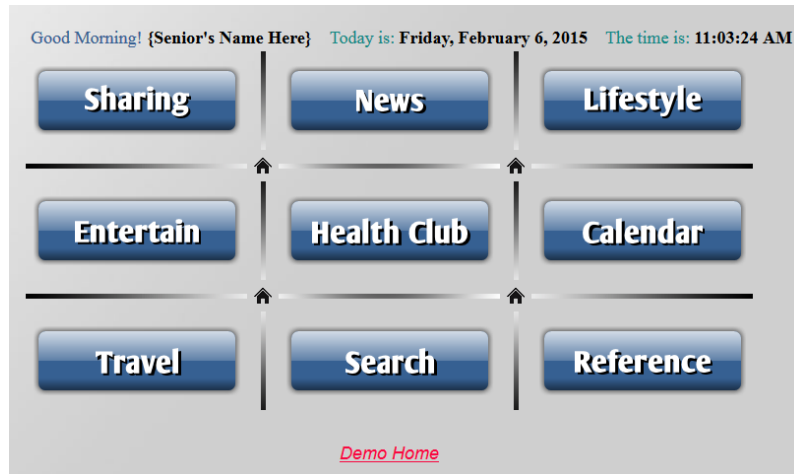


Figure 2.7: Application main interface [Sen15a]

2.7.6 Claris Companion

Another tablet designed for senior citizens is Claris Companion [Cla15], from Samsung. It allows seniors to communicate with their caregivers and it provides many features, including a dashboard calendar, video calling, email and text messages, photos and videos, medication and calendar reminders and Web browsing.



Figure 2.8: Claris Companion main screen [Cla15]

With respect to the Web browser, their website states: "Remotely configure access to any website so your loved one can get information on local services and keep up-to-date with news

from around the world. Each website is accessible on Companion by touching a large button that you can name, examples include the Weather, Shopping, Banking, Games, Google, etc. . . .".

2.7.7 GoLivePhone

The GoLivePhone [Goc15] is an extremely user-friendly smartphone, developed for seniors, aiming at making their lives more pleasant, easier and safer.

Their website states that the following features are available:

- Calling and video calling, text messaging, sending emails and Internet access;
- Photos, videos and gallery;
- Navigation, location tracking and "favourite places";
- Intelligent fall detection;
- Insight and feedback on how active one is;
- Emergency button and "I'm fine!" button;
- Automatic alerts (medication, meetings, reminders, activities);
- Intelligent geo-fencing;
- The home screen is fully customisable to one's experience level and preference;
- Remote care and monitoring with respect for one's privacy.



Figure 2.9: GoLivePhone interface [Goc15]

As can be seen in the Figure 2.9, the main screen has large icons for easy access to applications and provides useful information on the top bar. This product could benefit from having an application for Web browsing.

2.8 Summary

This chapter made an overview of older adults physical and psychological characteristics that may influence Web interaction and that need to be considered when designing an application for this type of users. Besides, current technologies that can be used in the scope of this project were presented and an analysis of existing similar products was made.

Literature review revealed that the use of the Internet may help overcoming the feeling of isolation and solitude, promoting the well-being of the elderly. Although older adults consider the Internet as a form of learning and entertainment, they feel discouraged by their lack of knowledge and might be reluctant to surf the Web, due to complex designs and interaction. Therefore, it is essential to take special attention to these problems, while designing applications for novice users, like older adults.

Chapter 3

Methodology

Human-Computer Interaction (HCI) is “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” [HBC⁺92]. Based on the principles, knowledge, methods and techniques of this research area, the work in this thesis aims at developing a product that considers older adults’ characteristics, so they can take full advantage of the benefits that technology has to offer them.

This chapter describes the HCI methodologies and techniques followed to undertake this master thesis.

3.1 User-Centred Design

User-Centred Design (UCD) is an HCI methodology that puts the user at the centre of the design process. By involving users in the design process, their expectations become more realistic, i.e., there are no surprises or disappointments related to the product. Besides, users get a feeling of ownership, making them more likely to forgive or accept problems [RSP11].

As can be seen in Figure 3.1, UCD consists of five stages: plan, research, design, adapt and measure [Gui]. For each of these phases, there are several HCI techniques that can be used, namely: user research, user requirements gathering, interviews, low-fidelity and high-fidelity prototypes and usability testing. These techniques are further explored in the following sections.

3.1.1 Plan

Planning is crucial to the success of all projects. In this phase, all UCD activities must be determined and it must be ensured that all the necessary resources are available. Thus, in the development of this project, all the methods to be used in the other stages were chosen, after an analysis of the existing techniques, and it was also planned how the direct contact with the elderly would be made, determining the tests’ environment.

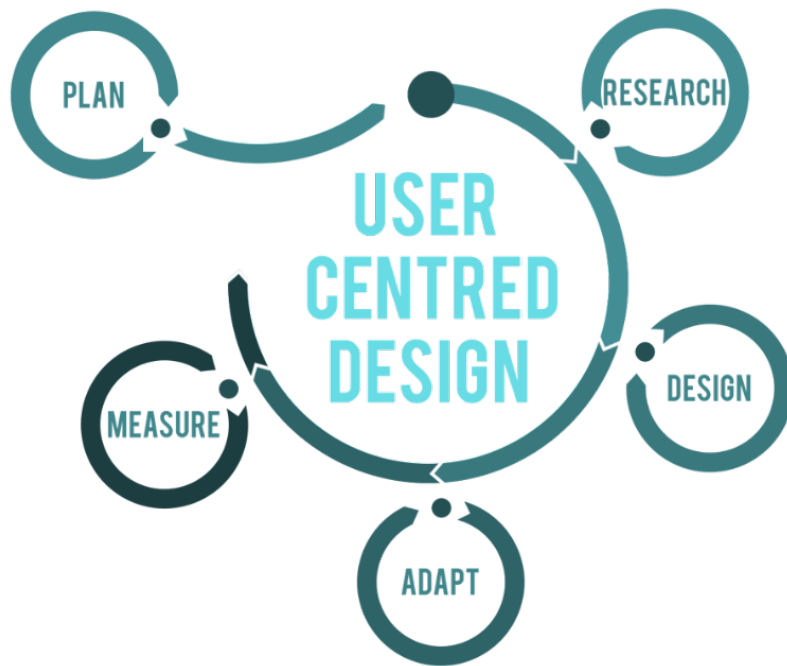


Figure 3.1: The process of UCD [Mas14]

3.1.2 Research

Before starting designing a product, it is essential to understand what the users' goals are, as well as tasks and market needs. It is also important to review and analyse related work in a given domain. In this project, user research was made, as well as an analysis of the existing similar products. The information gathered with these studies was complemented with interviews made directly to older adults.

3.1.2.1 User research

In the initial phase of the UCD process, user research was performed to understand and specify the context of use, since this method allows to better understand the target audience of the project. This was done through an in-depth literature review on older adults' characteristics and behaviours towards Web interaction, as well as on guidelines for designing for older people. This phase was crucial for acquiring solid background in order to proceed to the next stage.

3.1.2.2 Interviews

Interviews are another method for gathering relevant data, which allows exploring issues by, for example, using sample scenarios of use and prototypes [RSP11].

Usually face-to-face (although not mandatory), interviews involve asking someone a set of questions and can be classified into three main categories, depending on how rigorously the interviewer follows a prepared set of questions: structured interviews ("just the facts"; efficient and requires training), unstructured interviews (a conversation; inefficient, but does not require training) and semi-structured interviews (which start with focused questions and evolve to open-ended discussion) [RSP11].

This method can have better results if done in the interviewee's work or home setting, since people may feel more comfortable to talk about their activities. Furthermore, context can also enable them to remember certain aspects that they would not remember if the interview was taken elsewhere [RSP11].

This technique was chosen for being considered efficient with regard to the relation between time consumption and information gathering. Its implementation with the seniors is shown in chapter 4.

3.1.3 Design

In this phase, the system is defined from the user's perspective. This is firstly done through use cases describing the tasks that the system will support. Then, UI designs are created, starting with simple sketches and then moving on to detailed UI design specifications. Card sorting and prototypes were the main techniques used in the design stage. The following sections describe these techniques.

3.1.3.1 Card sorting

Card sorting is a process that "involves sorting a series of cards, each labelled with a piece of content or functionality, into groups that make sense to users or participants." [Spe04]. This UCD method was used in a very simplistic way: the users were provided a series of cards with different icons and naming conventions, and they were asked to choose the ones they thought were the most appropriate for the functionality they would define. The demonstration of this technique can be seen in chapter 4.

3.1.3.2 Prototypes

Users often cannot tell what they want, but when they have an idea of how the system works and what it can do, they are quickly able to say what they do not want [RSP11].

Prototyping is really helpful in the design process, because it allows answering questions and it supports designers in choosing between design alternatives. Thus, prototypes are useful for testing the feasibility of an idea, to clarify some vague requirements and to perform usability testing and evaluation [RSP11].

There are two kinds of prototypes: low-fidelity prototypes (sketches and mock-ups) and high-fidelity prototypes (which run in real devices, having the look and feel of the final product)

[RSP11]. Unlike high-fidelity prototypes, a low-fidelity prototype is simple, cheap and quick to produce and it does not look like the final product [RSP11].

The use of low-fidelity prototypes is encouraged, because they are easier and quicker to produce. Moreover, they solve some problems that occur with the use of high-fidelity prototypes: user and developer reluctance to make suggestions and changes, user focus on graphic details rather than on the "big picture" and high expectation on software prototype [RSP11].

With that said, high-fidelity prototypes are useful for selling ideas and for testing technical problems and low-fidelity prototypes are better for exploring content and structure issues. Hence, low-fidelity prototypes should be used in early stages of the process, while high-fidelity prototypes should be used later in the process [RSP11].

The implementation of both low- and high-fidelity prototypes, in the scope of this project, can be seen in chapters 4 and 5, respectively.

3.1.4 Adapt

The adapt phase predicts that every design may need to be adapted, either because of unanticipated technological limitations or missing functionality, or because of new requirements that may arise in the meantime. This stage took place throughout the development process, especially after the initial tests, when it was discovered that some minor changes needed to be made to the initial design. These changes are described throughout chapter 5.

3.1.5 Measure

In this stage, usability evaluation is made, measuring the product's effectiveness, efficiency, and satisfaction. Usability evaluation, as the name indicates, is a method used to evaluate the usability of a system or product, i.e., to check that users can use the product and that they like it. When conducted iteratively, all along the design and development lifecycle (as it is supposed to), it results in an improved product and a better understanding of the users' needs and wants [RSP11].

There are two main forms of evaluation: formative evaluation, when evaluation is done during the session, and summative evaluation, when evaluation is done on finished products to assess if all requirements are met and to collect information for future developments [RSP11].

There are several techniques with which one can perform usability evaluation. In this project, the Wizard of Oz was used to evaluate the initial paper prototypes and then, later in the development process, usability testing was done on the working prototype. The following sections describe these in further detail.

3.1.5.1 Wizard of Oz

Wizard of Oz is a technique in which the facilitator simulates the system's responses. In this project, this technique was used to evaluate paper prototypes (used early in the development process), with the facilitator switching prototypes or adding/removing pieces of information to the screen. Further details on the implementation of this technique can be seen in chapter 4.

3.1.5.2 Usability testing

Usability testing is a usability evaluation method that involves measuring typical users' performance on typical tasks. This is done by selecting representative users (usually 5 to 10 users) and developing representative tasks (typically, lasting no more than 30 minutes) [RSP11].

As users perform tasks, they are watched and recorded on video (informed consents required, to explain procedures and deal with ethical issues) and this observational data is later used to measure performance (usually calculated through the number of errors and time to complete the task), as well as identify errors and help to understand why users made a certain action. In order to have a reliable result, test conditions should be the same for every participant [RSP11]. In addition, interviews and user satisfaction questionnaires can be used to gather participants' opinions.

This method was used to evaluate the usability of high-fidelity prototypes, which were used at the final stage of the prototyping phase, running on a smartphone and on a tablet, with the look and feel of the final product, being completely functional and interactive. A protocol was created to be followed during these tests (which can be seen in Appendix D), which had the description of the tasks to be performed, as well as the ideal flow for completing the tasks and the performance and satisfaction metrics. In addition, a small questionnaire was administered to the participants, after they completed the tests, in order to gather their opinions. Chapter 6 shows the results of these tests.

3.2 Summary

UCD is a design process that involves end users from the beginning of the project, making it easier to design a system for older adults, while taking their needs and characteristics into account. The implementation of this methodology allowed to design a system adapted to seniors, by testing the low- and high-fidelity prototypes with them, thus giving a better insight on older adults' expectations and needs.

Methodology

Chapter 4

Designing a mobile Web browser for the elderly

Until this chapter, the state of the art analysis was presented (chapter 2), as well as the methodology used to develop the application (chapter 3). In this chapter, the data gathered from users is presented and analysed and a requirements specification is made. Then, the results from the first round of usability testing are detailed, displaying the initial (low-fidelity) prototypes of the system.

4.1 Gathering data from users

As mentioned in chapter 3, research is a crucial stage of the UCD process, in order to get as much information as possible about users and their needs and wants. In this phase, besides the user research through literature review, interviews were made to understand how older adults use the Web and to find out what are their main interests and challenges, while using this technology. These interviews were made through Fraunhofer's COLABORAR program [Col15], which maintains a contact network of centres where seniors spend most of their day, making it easier to reach the target audience.

Interviews took place at a social centre and followed a script (available in Appendix C) with 8 questions that aimed at learning participants' name, age, level of education, and information about his/her use of the Internet and touchscreen devices. These interviews not only informed design decisions, but also helped to establish a relationship with the participants.

A total of 10 seniors were interviewed, with ages ranging from 69 to 89 years old (Figure 4.1 displays participants' age distribution). All of these participants used eyeglasses, which means they all had some degree of visual impairments. As for the level of education, only two of the participants had never had any kind of formal education, five had a basic level of education, and the remaining three had completed high school. Figure 4.2 displays the distribution of the participants' level of education.

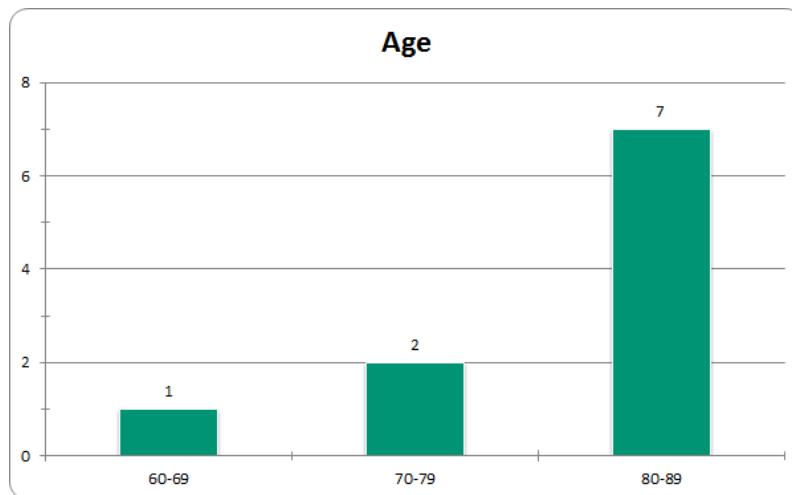


Figure 4.1: Test participant ages ranged from 69 to 89, with an average age of 79.6

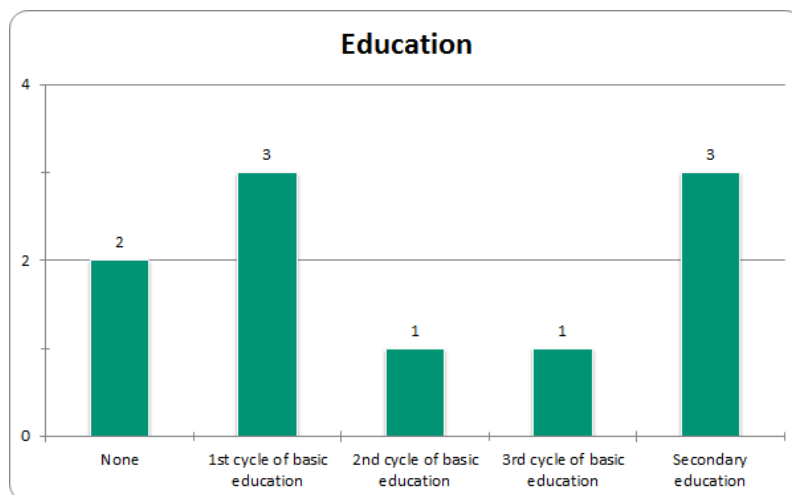


Figure 4.2: Test participants' level of education ranged from no formal education to secondary degree

Regarding touchscreen device usage, only two of the participants owned a smartphone, two had never used a touchscreen device, and the rest had only used tablets or smartphones during some activities in the social centre. The most frequent reason for not owning a smartphone was the fact that the elderly only used their phones to make and receive calls and did not see any advantage in using a smartphone for that; as for the use of tablets, most stated that they did not know how to use it or that it was too expensive. Also, when asked if they felt any difficulty while using touchscreen devices, no one revealed any trouble, except for one person who said that tablets are heavy. Figure 4.3 displays participants' reported touchscreen device usage.

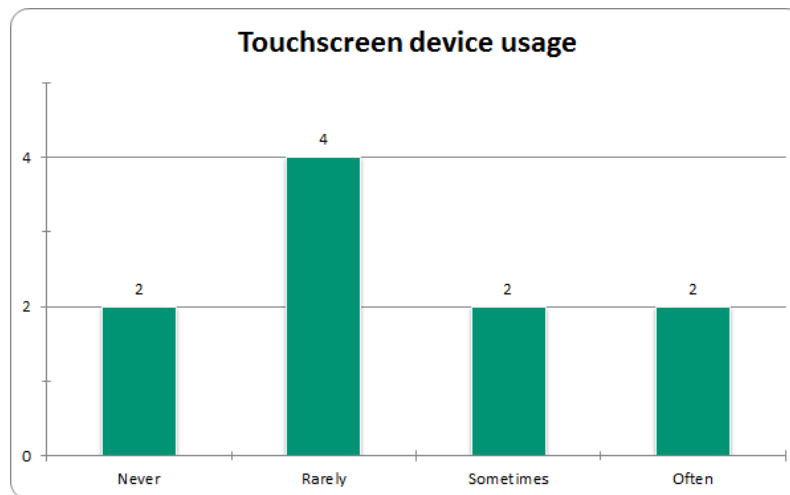


Figure 4.3: Test participants' touchscreen device usage ranged from never using such a device to frequent use

Lastly, participants were asked about their Web usage patterns. As can be seen in Figure 4.4, only two of them used the Web frequently. For the ones who usually did not navigate on the Web, the most common reasons included not owning a computer, being afraid of damaging the machine, not knowing what to do or being afraid of doing something wrong, and finding it too confusing with many options, buttons and difficult mouse interaction.

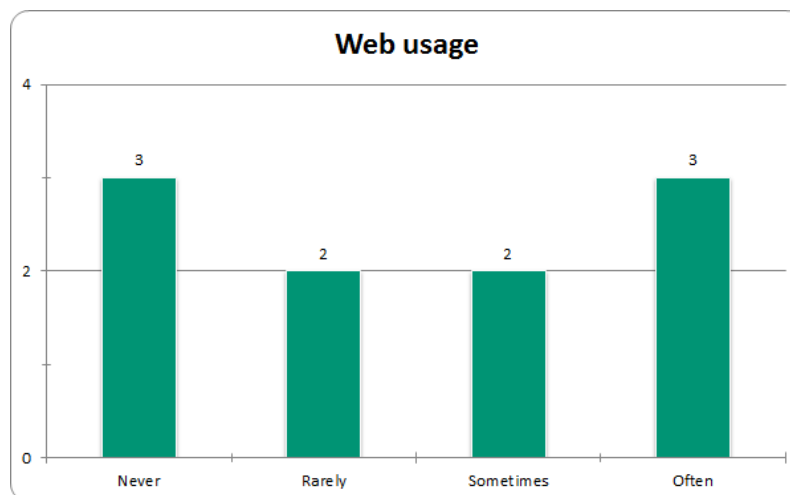


Figure 4.4: Test participant's Web usage ranged from never using it to frequent use

Both Internet users and non-users were asked about what kind of information they sought the most, giving dispersed answers, such as health topics, news, recipes, videos, music, weather, dictionary, and touristic and cultural information.

Analysing this data, it can be concluded that most older adults have little or no contact to mobile and Web technologies, with the lack of knowledge and lack of confidence being the most frequent reasons for it. This information confirms the findings obtained during the literature review phase, described in chapter 2. Therefore, it became even clearer that special attention is required when designing applications for these type of users, so they can take full advantage of technologies' benefits, thus improving their well-being and independence.

4.2 Requirements specification

Before starting designing the mobile application, which was called EzNav, and based on the literature review, it was important to establish the requirements. In this section, both functional requirements – which describe what the system should do - and non-functional requirements – which describe how the system works – of the EzNav application are detailed. The initial set of requirements (defined through an analysis of literature review) was refined after the interviews, leading to the establishment of the requirements presented here.

4.2.1 Functional requirements

4.2.1.1 User requirements

Being an elderly, the user needs to be able to:

- Open a category of webpages (initially available categories are: favourites, news, health or useful; but can be more);
- Open a webpage from the existing webpages in a given category;
- Add a webpage to a category of webpages;
- Remove a webpage from a given category;
- Set the order in which the webpages appear inside each category;
- Search for any kind of information on the Web;
- Open any webpage, by typing the URL on the address bar;
- Open a webpage from a list with the webpages he/she visited the most.

4.2.1.2 Technical requirements

- Internet access.
- A tablet or smartphone device running Android 4.4 KitKat or newer, because of the security flaws found in pre-KitKat Android WebView that were mentioned in section 2.4.2.1.

4.2.1.3 System requirements

- When some action is performed successfully or when some failure occurs, the application should give quick and proper feedback, displaying some message (e.g. when a webpage is saved successfully or when there is no Internet connection)
- The application should provide proper feedback when the user performs some action (e.g. highlight a pressed button).
- When leaving an activity without saving entered data, the application should ask the user if he/she wants to save that data.
- When deleting a webpage, the application should ask the user for confirmation.
- The application should use a database to store all visited webpages, in order to display a list of the most visited ones.

4.2.2 Non-functional requirements

- Usability - Usability is one of the most important qualities of a system, particularly when designing for older people. Users must be able to easily identify every available functionality and to use the application with confidence. Usability tests must be done having seniors at the centre of the design and development process, to try the best to adapt the application to their needs and knowledge. The application interface must be simple and consistent, providing visible and understandable information, and being sufficiently intuitive so users can be quickly involved in its usage. Also, existing usability guidelines should be followed whenever possible.
- Extensibility - The system should allow for a relatively easy integration of new features as well as editing and updating the existing ones.
- Reliability - Users must be able to trust the system and use it with confidence. This means the system needs to be reliable, without failing or providing any wrong information.
- Robustness - Although errors must be avoided, the system needs to be able to cope with them, informing the users of the impossibility of doing something, if necessary.

4.2.3 Use cases

The use case diagram depicted in Figure 4.5 is a graphical view of all the functionalities that seniors can access, while using the application.

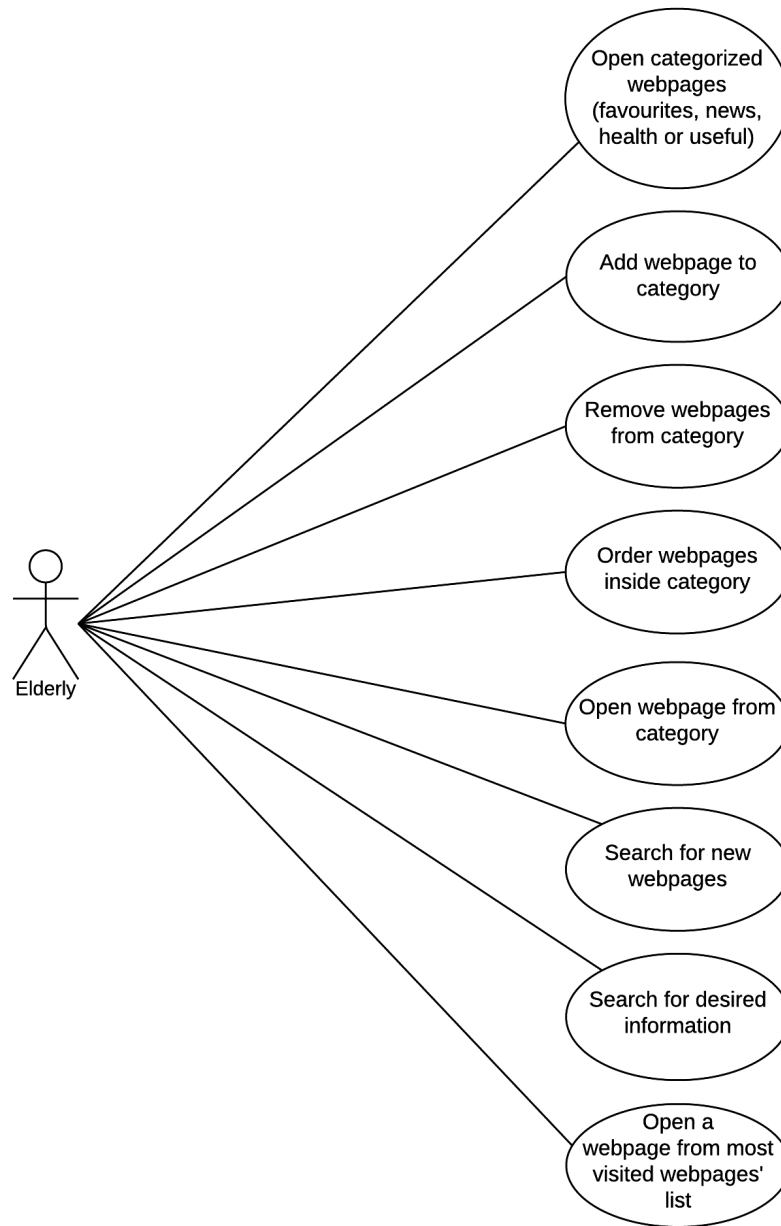


Figure 4.5: Use case diagram

4.3 Initial prototype evaluation

In the initial stage of the design process, paper prototypes were developed and tested with the elderly. This technique allowed not only to validate the requirements defined in section 4.2, but also to assess the usability of the UI, so that improvements could be done, if needed. Figures 4.7 to 4.13 depict the application's low-fidelity prototypes, for the smartphone. The mockups used for the tablet can be found in Appendix E, as well as the portuguese versions of both.

Designing a mobile Web browser for the elderly

The main screen interface is constituted by 5 buttons: 4 categories and the search functionality. These categories are divided into: favourites, news, health and useful. News and health categories were chosen for being the type of information elderly users most seek for, according to literature review. Favourites, as the name suggests, is a category to which users are supposed to add their favourite webpages. Finally, useful category, as described later in this section, was selected for having webpages that older people consider useful, but that do not fit into the other categories. If proven necessary, other categories can be added in future versions.

The displayed prototypes were printed, so that the first round of usability testing could be made. To do that, six seniors were asked to perform six tasks, with the test facilitator switching the prototypes or adding pieces of information to the paper screens, as actions were performed.



Figure 4.6: Usability testing with older adults, using paper prototypes and Wizard of Oz technique

The tasks requested of the seniors are presented below.

Task 1: Open a webpage from "News" category

Task 2: Go back to "News" category

Task 3: Add a webpage to "News" category

Task 4: Remove a webpage from "News" category

Task 5: Order the webpages in "News" category

Task 6: Go back to application main screen

Task 7: Search for a certain information on the Web

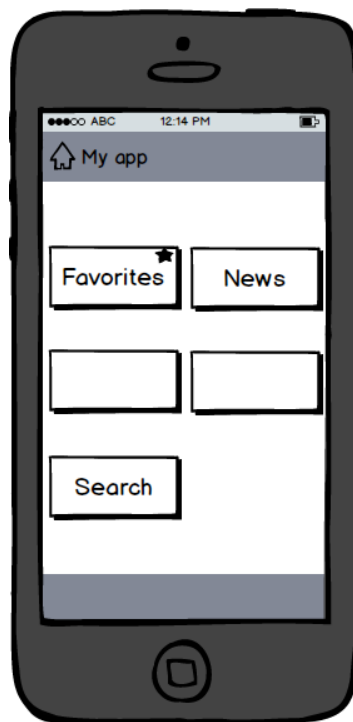


Figure 4.7: Application main interface



Figure 4.8: Interface for the "News" category

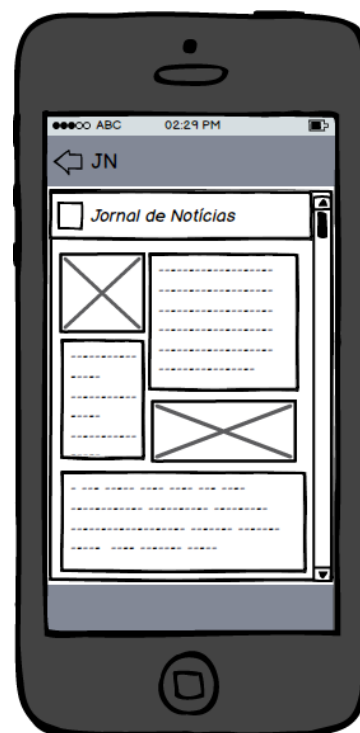


Figure 4.9: Example of a "News" webpage



Figure 4.10: Interface for adding a new webpage to a category

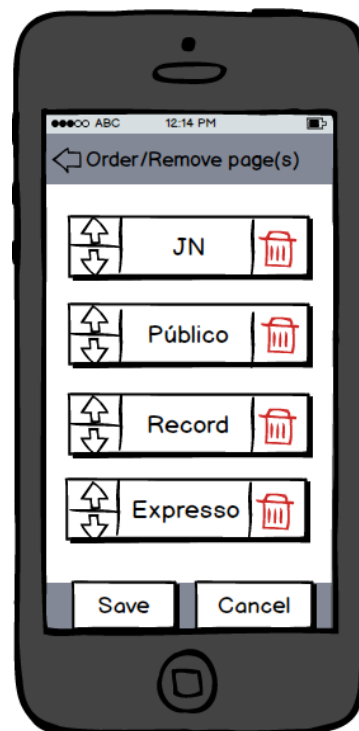


Figure 4.11: Interface for ordering and removing webpages from a category

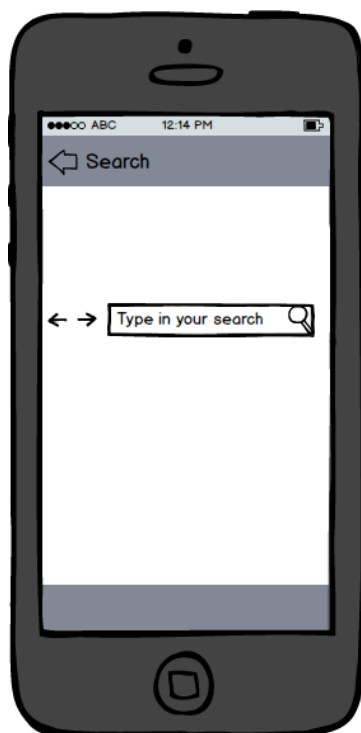


Figure 4.12: Interface for the search functionality



Figure 4.13: Example of search results

Tasks 1, 2, 3, 4, 6 and 7 were successfully performed by all seniors, with no effort. As for task 5, three of the six seniors dragged the webpage they wanted to go up or down in the list, instead of clicking the up/down buttons to order it. For this reason, and also taking advantage of existing studies in the scope of Smart Companion / GoLivePhone projects, drag and sort functionality was adopted instead.

Since there were no significant changes to be made to the initial design, the second round of usability testing was left for later in the process, with a high-fidelity prototype.

Besides the usability tests, card sorting was used to define the correct names and icons for each functionality of the system. Participants were firstly asked what name they would give to the application main screen, from a list with three alternatives: "Internet" ("Internet"), "Browser" ("Navegador") and "Web" ("Web"). "Internet" was chosen by all the ten participants.

Next, seniors were asked what name they would choose for a category with their favourite webpages, within four alternatives: "Favourites" ("Favoritos"), "Saved" ("Guardados"), "Bookmarked" ("Marcados") and "Selected" ("Seleccionados"). From a set of ten test users, seven chose "Favourites" and three chose "Selected".

As for the search functionality, participants were asked what name they felt was the most appropriate: "Find" ("Procurar"), "Search" ("Pesquisar") or "Explore" ("Explorar"). Six of them chose "Search", three chose "Find" and only one chose "Explore".

Then, older adults were asked to choose the name they would give to the functionality that allows one to order or remove webpages from a category. The existing alternatives were: "Manage webpages" ("Gerir páginas Web"), "Organize webpages" ("Organizar páginas Web") and "Order / Remove webpages" ("Ordenar / Remover páginas Web"). Nine of the ten older adults chose "Order / Remove webpages" and one chose "Organize webpages". Considering these results, they were then asked what name they would choose for each of these functionalities, in separate. For the ordering functionality, two alternatives were given: "Order" ("Ordenar") and "Change" ("Trocar"), and eight of the test users chose "Order". As for the remove functionality, the alternatives given were: "Eliminate" ("Eliminar"), "Remove" ("Remover") and "Delete" ("Apagar"). From the set of ten participants, nine chose "Remove" and one chose "Eliminate".

Finally, as stated in section 4.1, there was not a consensus on the kind of information older adults most seek for. For that reason, it was decided to have a fourth category, with webpages that do not fit the other categories and that are considered useful for this type of users. Thus, test participants were asked what name they would give to this category, from a list with three alternatives: "Useful" ("Úteis"), "Others" ("Outros") and "Several" ("Vários"). Only one participant chose "Several", two chose "Others" and seven chose "Useful".

Additionally, seniors were asked to suggest other names for each functionality. However, suggestions received were not considered, since they were not significant (only two participants made name suggestions, and only for one functionality each).



Figure 4.14: Applying card sorting with older adults, to choose appropriate icons for each functionality

After identifying which were the most adequate names for each functionality, participants were asked to choose the icon they felt was the most appropriate for each one of them. Tables 4.1 to 4.6 depict the icons shown to the elderly and the number of participants that chose each icon.

Table 4.1: Icon selection for EzNav logo

0	3	2	1	4

Table 4.2: Icon selection for "Favourites" category

1	5	2	0	1	0	1

Table 4.3: Icon selection for "News" category

4	5	1

Table 4.4: Icon selection for "Health" category






				
0	0	2	7	1

Table 4.5: Icon selection for "Useful" category







		
3	1	6

Table 4.6: Icon selection for "Search" functionality

		
3	5	2

As can be seen in the above presented tables, these were the results of the card sorting for the icons: for the application icon, users chose the world symbol, since they feel that the Internet allows them to "see" the world; for the favourites, news, health and useful categories, the selected icons were a star, a newspaper icon, a heart and a toolbox, respectively; finally, for the search functionality, the magnifying glass was chosen.

By analysing all the data gathered with this usability testing, it could be concluded that there were no critical changes or improvements to be done. Thus, it was time to move to the next phase and start implementing the solution to later test it.

4.4 Summary

This chapter presented the requirements gathered from the literature review and from the interviews made to the seniors, as well as the initial usability testing.

Usability tests, in general, had very pleasant results. Each task helped to check if the application design was in the right direction and if the elderly could clearly understand every functionality. This was also achieved through the card sorting technique, to choose the names and icons that the elderly felt were the most appropriate for each functionality.

Next chapter describes the application development process.

Chapter 5

EzNav's implementation

After the analysis of the first round of usability testing, and since there were no significant changes to be made to the initial prototype, the next phase was to start developing the application.

This chapter details the implementation of the system, starting with a brief description of the physical system architecture. Then, the design decisions are presented as well as the customizations made to webpages to improve Web interaction.

5.1 Architecture

In Figure 5.1, the physical system architecture diagram can be seen.

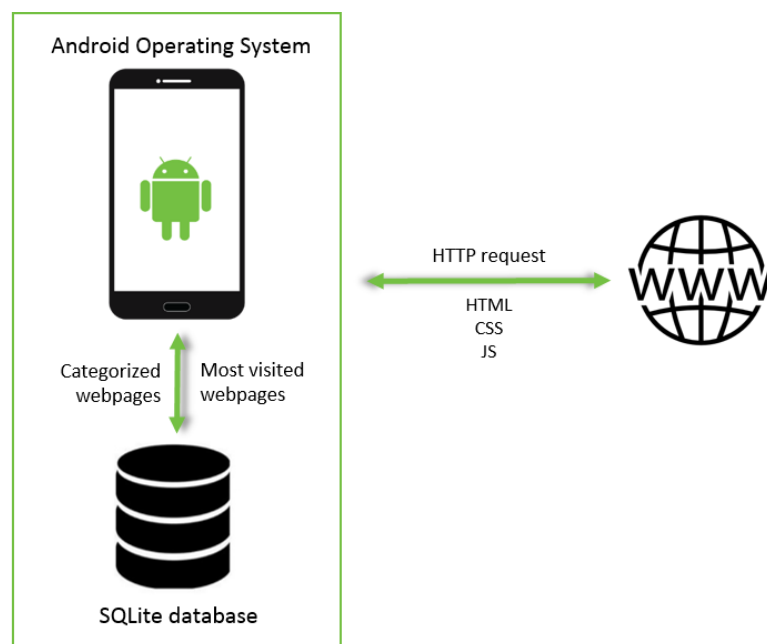


Figure 5.1: Physical architecture diagram

EzNav's implementation

The system is composed by an Android application that makes HyperText Transfer Protocol (HTTP) requests to display webpages in a WebView, and then injects JavaScript to make customizations to these webpages. A SQLite database is also used for storing the webpages added to a given category (in this case, favourites, news, health and useful) and also for saving a history of the visited webpages, so that a list of the most visited webpages can be shown to users, when they open the search screen.

The logical architecture diagram depicted in Figure 5.2 illustrates EzNav's organization.

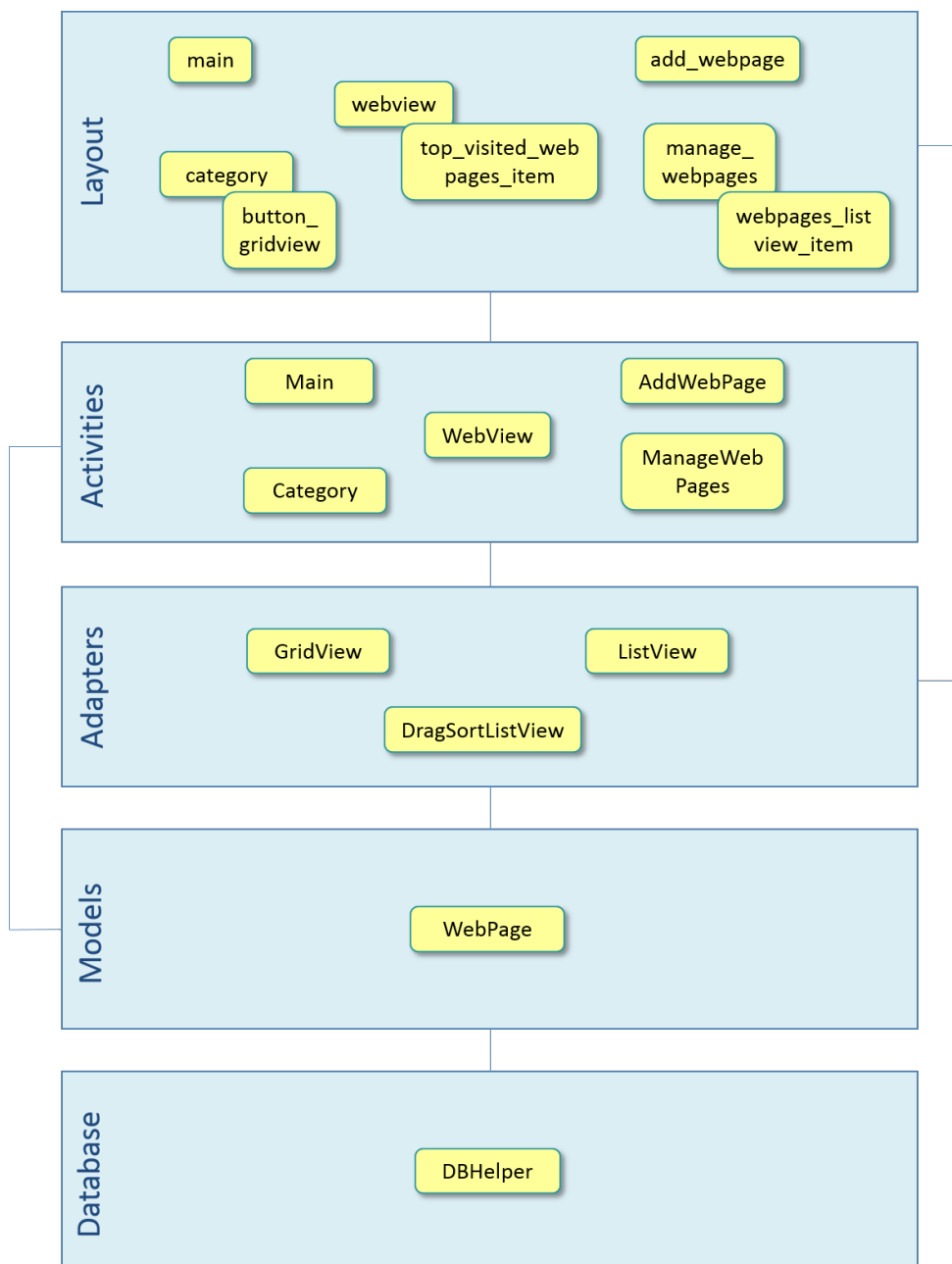


Figure 5.2: Logical architecture diagram

The application is divided into five main components that interact with each other:

- **Database:** A helper class is used to provide an abstract layer between the database and the activity class, with the database layer providing methods used by the activity, like adding or removing a webpage from a category. Thus, this class is responsible for the creation and management of the webpages in the database.
- **Models:** In order to implement the above-mentioned interaction, a data model representing a webpage was created to hold the database entry data as it is passed between the helper and the activity.
- **Adapters:** Adapters are used to make the bridge between the AdapterView (e.g., GridView and ListView) and the underlying data for that view. In this case, they interact with the model and layout layers, to fill in the GridView with the webpages within a category and the ListView with the most visited webpages.
- **Activities:** An Activity is a component that delivers a screen with which users can interact with the application. This layer fetches the information passed by adapters and by the layout files, to present the necessary information, options and resources for each application screen.
- **Layout:** The layout layer is responsible for creating the user interface for each activity, by providing a hierarchy of views.

5.2 Application development

The Android mobile operating system (OS) was the chosen one to develop this work, because, besides all of the Android's characteristics described in chapter 2, EzNav was implemented as a module of the Smart Companion and GoLivePhone project, which uses Android OS.

Since the application consists of a mobile Web browser, the WebView is used to display the webpages. As already mentioned in section 2.4.2.1, security flaws have been detected in WebView version 4.3 and lower. For this reason, the minimum system version (minSdkVersion) for using this application was set to API 19 (Android 4.4 KitKat). However, it is advisable to use the application in a device running Android 5.0 Lollipop or higher, since it allows users to do updates from Google Play, thus ensuring they get the latest enhancements and bug fixes for WebView [Mei15].

EzNav supports both English and Portuguese languages and it can be easily expanded to support new languages. The language to use is based on the system language, English being the default language, in case the system uses a language not supported by the application.

The application was tested on a LG G3 with a 5.5" Quad high-definition (HD) (2560X1440) in-plane switching (IPS) screen and on a Samsung Galaxy Tab S with a 10.5" Wide Quad Extended Graphics Array (WQXGA) (2560x1600) screen.

5.2.1 Senior-friendly design

The application design aimed at being simplistic and easy to learn and understand, especially because most elderly people had little to no experience with smartphones and tablets. Central to this ideology was the need for simple screens, including only essential functionality for a mobile Web browser and following a set of layout rules to ensure consistency across the system, with well-defined conventions for the position of information and buttons.

With these needs in mind, every application screen is divided into three main components: at the top, there is a header with a concise and descriptive title so the user can know where in the application he/she is or what he/she can see or do in that screen (e.g. "Search", "Add webpage"); in the middle of the screen is the main content (e.g. a webpage or a list of webpages); at the bottom are the buttons that represent the possible actions the user can perform (e.g. "Add webpage", "Order/Remove webpages"). In addition, every screen includes a customized and senior-friendly status bar.

Besides these rules, and in order to provide high contrast (negative polarity) and improve legibility (as explained in section 2.2.1), light text colour is used on dark background.

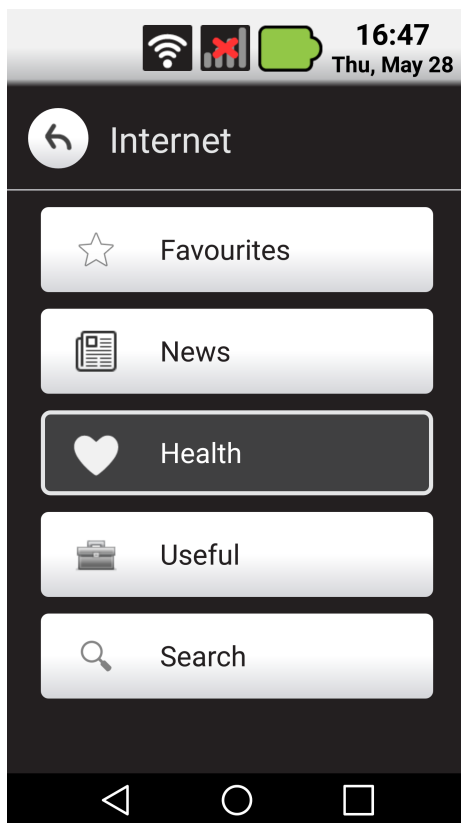


Figure 5.3: Application main screen, with "Health" button pressed

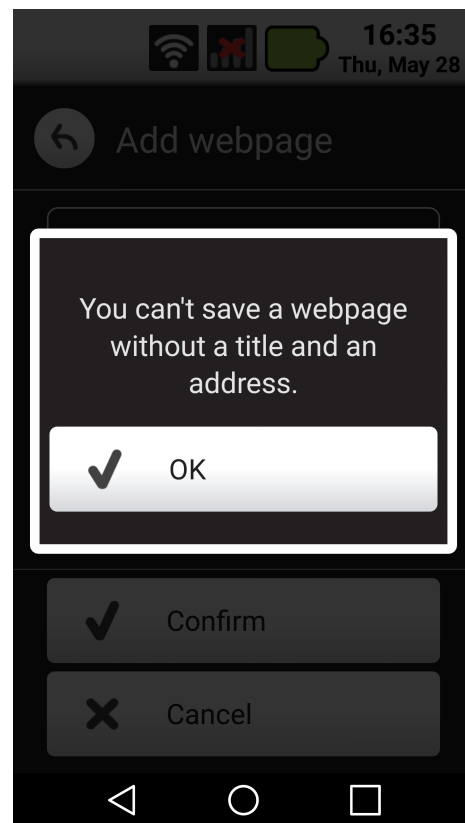


Figure 5.4: Dialog informing the user that an action cannot be performed

Big buttons and large font sizes are favoured, so that users have no difficulties reading or tapping the options. Also, when the user presses some button, feedback is given by inverting the

colours of that button and of the elements (text or icons) contained in it, so the user can easily understand that the button was, indeed, pressed. Furthermore, EzNav has a variety of dialogs to inform the user that some action was executed or to ask for confirmation, while performing some action (e.g. ask for confirmation when the user deletes some resource). Figure 5.3 shows the feedback for when a button is pressed; Figure 5.4 displays a dialog, informing the user that the action cannot be performed; behind the dialog, the previously mentioned screen division can be seen.

Finally, a custom and simplistic error page was created, to inform users when there is no Internet connection, as can be seen in Figure 5.5.



Figure 5.5: Custom error page

At the moment, the application only supports portrait orientation. Some devices do not show big differences if used in portrait or landscape orientations, but some smaller tablets or smart-phones do, possibly leading to unexpected and inadequate layout presentation. Designing for landscape orientation would require an additional effort, both in the development and in testing with the users, to find out how to take advantage of the available space. Given the short timeframe, this could not be accomplished in the scope of this project.

5.2.2 Customizing webpage presentation to improve Web interaction for seniors

Even though designing a senior-oriented application theoretically improves Web interaction for older people, there is a need for customizing webpage presentation for these users. This happens because, although there are many accessibility guidelines for designing Web applications, many websites do not adhere to them, or if they do, some assume that users are familiar with the technology. Besides, what is beneficent for one user might be counter-productive for another. Thus, Web interaction for elder users (and, in fact, for other types of users) would be improved if webpage presentation was also personalized to fit an individual's needs.

As mentioned in chapter 2, several studies have been performed on the ageing-related changes and their impact on Web interaction, and there are already many guidelines to fight these impairments, namely: using 12- or 14-point font size, maximizing information/background contrast in critical areas, presenting important information as close to the centre of the screen as possible, presenting text in small blocks and making an effective use of white spaces, using negative polarity, and avoiding ads as well as moving and flashing objects.

Considering these guidelines, EzNav aims at enhancing Web browsing experience, by improving webpage's content presentation and adapting the browser to fit older adults' needs.



Figure 5.6: "Público" original webpage



Figure 5.7: Same webpage, after customization

As explained in chapter 2, as people get older, there is a retinal efficiency reduction that leads

to a decreased capability to adapt to glare. For this reason, the first customization to be made was to implement negative polarity (light coloured text on dark coloured background) to webpages, making them more readable for older adults. Another condition that arises with ageing is the yellowing of crystalline lens, which makes it easier to see oranges, reds and yellows. This is why orange was the selected colour for highlighted information, such as news titles. Figures 5.6 and 5.7 show a webpage, before and after applying the customization, respectively.

Another customization made was to slightly increase the spacing between blocks of text, so that seniors can easily identify where a block of text ends and another begins, thus improving legibility in webpages. An example of this can be seen in Figure 5.7, next to the circle with the letter "B". This, as the negative polarity, was done by injecting JavaScript into the WebView, adapting the webpage's CSS.

Also, according to Kurniawan and Zaphiris [KZ05], in order to improve Web interaction for older adults, advertisements should be avoided, since seniors get easily distracted and this prevents them from focusing on relevant information. Thus, ads are removed using a JavaScript function that looks for elements that contain suspicious keywords, like "ads", "pubs" or "advertisement", and hides/removes them. Although this still needs to be further improved, current results can be seen in Figure 5.7, next to the circle with the letter "A".

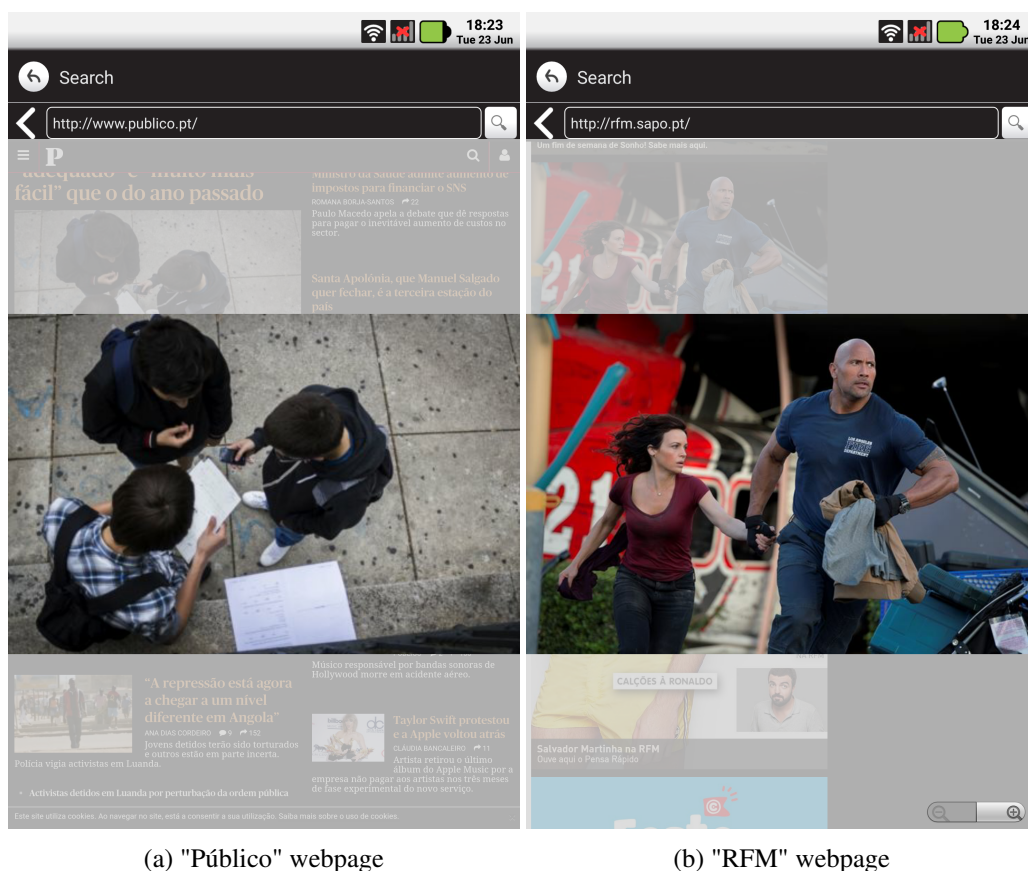


Figure 5.8: Displaying an enlarged image, after the user has pressed the original one

Finally, JavaScript is used to make the connection between Android and the HTML and CSS of webpages. Taking advantage of this, users can see enlarged images, by long pressing them in the webpage, and then clicking anywhere on the webpage (including the expanded image) will reduce the image to its original size. This is done by getting the image's source URL and presenting it in full screen size. Figure 5.8 illustrates this feature.

Besides all these customizations, the WebView's built-in zoom controls are activated, so users can zoom in or zoom out on a webpage by simply pressing the corresponding button, on the bottom right corner of the webpage (Figure 5.9). However, this does not work for all webpages, because some of them have a parameter in their viewport meta tag that removes the ability to zoom in or zoom out.



Figure 5.9: WebView built-in zoom controls

Since this application was developed as a proof of concept, its correct behaviour is only assured for a set of webpages.

The tested webpages were the following:

- Jornal de Notícias¹ - "News" category
- Público² - "News" category
- Diário de Notícias³ - "News" category
- Correio da Manhã⁴ - "News" category
- SAPO Lifestyle⁵ - "Health" category
- O Tempo para 14 dias Portugal⁶ - "Useful" category
- Dicionário Priberam da Língua Portuguesa⁷ - "Useful" category
- RFM⁸ - "Useful" category

The results of the customizations made to these webpages are demonstrated in Appendix G.

¹<http://www.jn.pt/paginainicial/>

²<http://www.publico.pt/>

³<http://www.dn.pt/inicio/default.aspx>

⁴<http://www.cmjornal.xl.pt/>

⁵<http://lifestyle.sapo.pt/saude/bem-estar>

⁶<http://www.tempo.pt/>

⁷<http://priberam.pt/dlpo/>

⁸<http://rfm.sapo.pt/>

As can be seen in chapter 7, the webpage content presentation could be further improved, in order to meet older adults' needs. However, making changes that act as expected in different contexts is very challenging. This occurs because webpages do not follow any strict rules to make them easily parsable in the same way, since element's classes, id's and other identification properties vary from implementation to implementation (even though they could represent the same type of element across different pages). Thus, and given the time that would be needed to make additional customizations and test them with the seniors, this was not possible in the scope and timeframe of this project. Nonetheless, this is undoubtedly worthy of additional analysis and development in the future.

5.3 Final prototype

This section details the application's main screens. Prototypes for both smartphone and tablet (portuguese and english versions) can be found in Appendix F.

As can be seen in Figure 5.10, the application starts with a menu that allows to choose a category of webpages (favourites, news, health or useful) or the search option.

To ease interaction, a SQLite database is used to store some pre-defined webpages, considered useful for older adults, for each category (except favourites). This way, seniors can access a collection of webpages with a simple touch. Figure 5.11 illustrates the use of categories ("news" category, in this case).

Each category allows to add new webpages, as well as removing existent webpages or change the order in which they appear. To add a new webpage, the user must select "Add webpage" option, specify the title and URL for that webpage and then save it, by clicking in "Confirm" button. Figure 5.12 displays the screen that allows to add a new webpage to a category.

Removing an existing webpage is done by clicking on the button with the trash bin symbol, next to the title of the webpage to be removed, after opening the "Order / Remove webpages" screen. In that same screen, users can choose the order in which the webpages appear, by holding the symbol on the right of the webpage they want to move and moving it to the desired position. As explained in chapter 4, section 4.3, the drag and drop feature was implemented, because it seemed the most intuitive way to order the webpages. The screen that allows to order and remove webpages is shown in Figure 5.13.

Finally, Figure 5.14 depicts the search screen. In this screen, a user can either go to a webpage, by typing its URL in the address bar, or search for a specific information, by typing the search term in that same field.

To ease interaction, users' most frequently visited webpages are recorded into a list, through the use of the previously mentioned database, allowing the application to adapt to each user's habits. This way, users can open a frequently visited webpage by simply selecting it from the list.

A back button, at the left of the address bar, allows for back history navigation. Forward navigation was not implemented, because seniors did not show any interest in that feature.

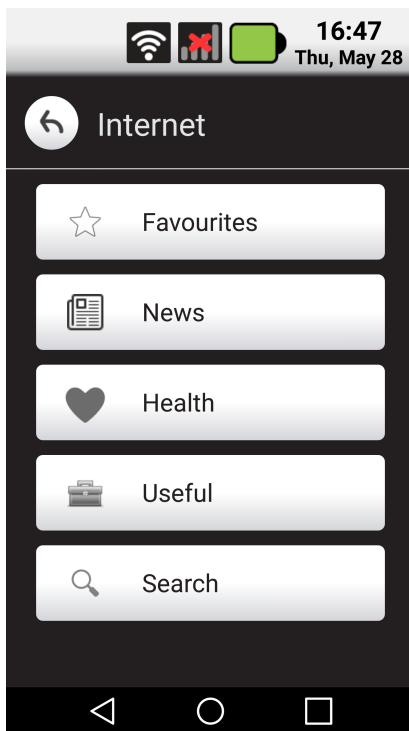


Figure 5.10: Application main screen

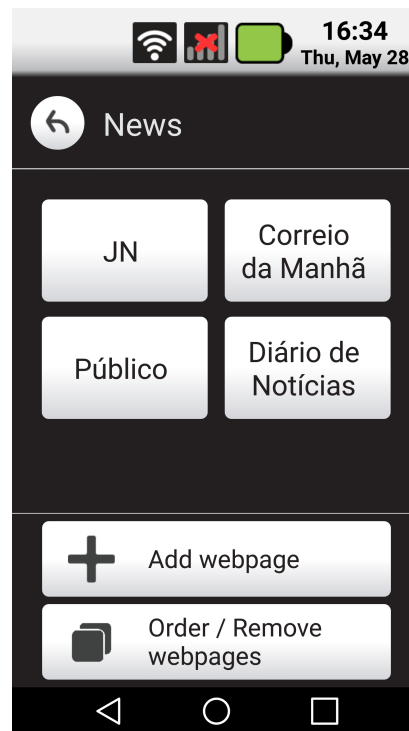


Figure 5.11: Screen that displays the webpages within a given category ("News" in this case)

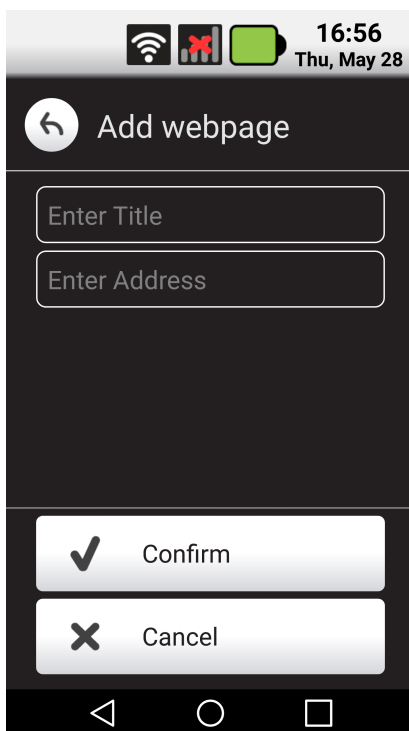


Figure 5.12: Screen for adding a new webpage to a category



Figure 5.13: Screen for ordering or removing webpages, within a category

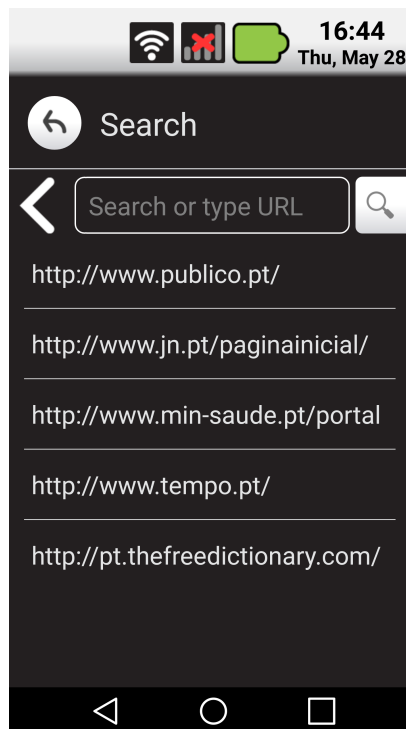


Figure 5.14: Search screen, with a list of the most frequently visited webpages

5.4 Summary

The current chapter presented the implementation details of the EzNav application.

A working prototype was implemented and tested with elderly users. The evaluation of this prototype can be found in the next chapter.

EzNav's implementation

Chapter 6

Evaluation and validation

After the application was developed, it was essential to test it again with elderly users to validate the solution, evaluating its usability.

This chapter describes the application evaluation process. It provides an overview of test participants' data, and presents the protocols followed for the usability tests as well as the results of these tests and of the usability questionnaires.

6.1 Final prototype evaluation

The final usability tests took place at a social centre and followed a usability testing protocol, available in Appendix D. This evaluation counted with the participation of ten seniors, with ages ranging from 61 to 92 years old, of which five had already participated in the first round of usability testing. As for the other five, they had similar touchscreen devices and Web usage patterns.

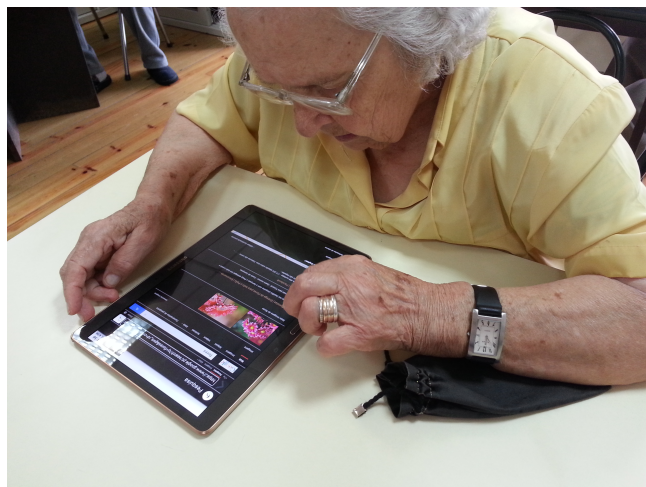


Figure 6.1: Final usability tests with seniors

Participants were asked to perform nine tasks, in order to validate the application design. Tests were made for both smartphone and tablet devices, assigning four users to the usability test with the smartphone and the other six users to the usability test with the tablet.

The following sections detail each task and its results. The figures representing the ideal flow for completing each task have a green border indicating the options that the user should choose in each screen. In some cases numbers can be seen, which identify the order in which the actions should be performed.

6.1.1 Usability tests

6.1.1.1 Task 1: Opening a webpage from a category

In the first task, participants were asked to open the "Público" webpage, an online portuguese newspaper. The goal of this task was to check if the seniors could identify the "News" category and open a webpage from that screen. As such, the intended flow for this task consists of two steps: open the "News" category and open the intended webpage. Figure 6.2 illustrates the ideal flow for performing this task.

All test participants completed this task, with no effort nor additional steps.

Furthermore, they were asked about their opinion in relation to the customizations made to the webpages.

Regarding negative polarity, two of the ten participants claimed that they preferred the original version, but they also liked the customized version. As for the other eight, they stated that they really liked this feature, since it increased the highlighting of words, thus improving readability. Some of these participants also mentioned that the reduced brightness helped to combat the feeling of tired eyes.

In relation to ads removal and increase of paragraphs spacing, all participants were happy with it.



Figure 6.2: Ideal flow for performing task 1

6.1.1.2 Task 2: Adding a webpage to a category

After opening the required webpage, seniors were asked to go back to "News" and to add a new webpage to that category, with a given title and address (in this case, "SOL" and "sol.pt"). This task aimed at identifying if users could find the "back" button, as well as the "Add webpage" functionality. Further, it was needed to check if seniors could fill in the required fields.

After going back to "News" screen, users should select the "Add webpage" functionality, fill in the fields, and then click "Confirm". Then, a dialog appears, informing the user that the action was successfully performed. The ideal flow for completing this task is displayed in Figure 6.3.

Of the nine users that could perform the tasks within the expected number of steps, one used the Android device back button. Only one participant could not complete the task through the ideal flow, choosing "Order / Remove webpages" instead of "Add webpage". However, this participant quickly understood that it was not the desired operation and hit the back button; then, the correct option was selected, but instead of clicking "Confirm" button to save the new webpage, the senior clicked on the back button and then chose option "Yes" when a dialog popped up asking "You didn't save your new webpage. Do you wish to save it now?".

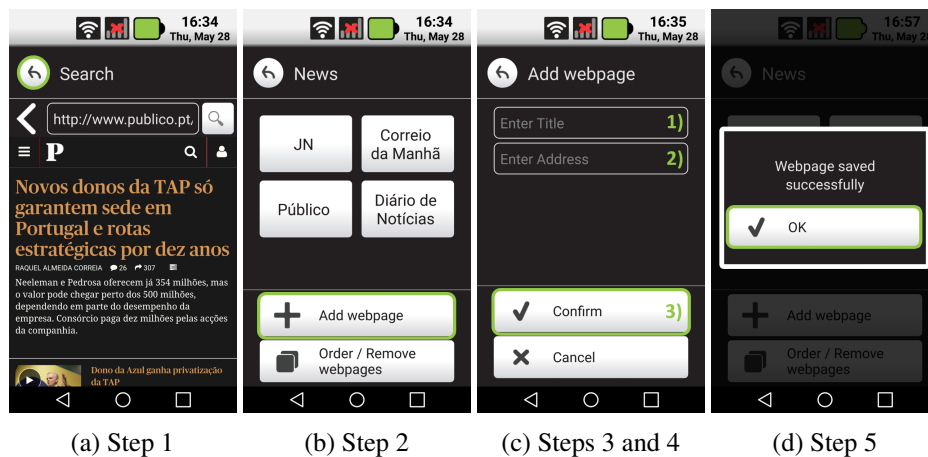


Figure 6.3: Ideal flow for performing task 2

6.1.1.3 Task 3: Removing a webpage from a category

In order to evaluate if the elderly could identify the functionality that allows them to manage webpages, they were asked to remove a webpage from the "News" category (in this case, "Diário de Notícias"). After choosing the "Order / Remove webpages" option, a list of the existing webpages in that category was shown to users and they had to identify the trash bin as the button to delete the desired webpage. After clicking in the delete button, a dialog was shown, asking for confirmation for performing that action. Figure 6.4 depicts the ideal flow to execute this task.

This task was successfully performed by eight of the ten test participants. The other two firstly opened the indicated webpage, but they rapidly understood that this was not what they intended to do, so they went back to the category and then did what was expected.



Figure 6.4: Ideal flow for performing task 3

6.1.1.4 Task 4: Ordering webpages within a category

Task number 4 aimed at evaluating if the seniors could identify the drag and drop gesture to reorder webpages' position in a given category. To do so, participants were asked to order webpages so that "SOL" could be the first one in the list. As one can see in Figure 6.5, after dragging the webpage to the desired position, users had to hit the "Confirm" button, to save the new order.

This task was successfully performed by all test participants.



Figure 6.5: Ideal flow for performing task 4

6.1.1.5 Task 5: Searching for a specific information in the Web

The goal of the fifth task was to ascertain if older adults were capable of identifying and taking advantage of search functionality. Participants were told to go back on the application screens and search for any kind of information. To complete this task, users needed to go back to the application main screen, choose "Search" option, type the query to be searched, and click the search button on the right of the address bar or on the soft keyboard. This flow is illustrated in Figure 6.6.

Evaluation and validation

Only one test participant did not perform this task within the expected number of steps. This happened because the senior selected "Favourites", instead of "Search". However, when facing an empty category, the participant rapidly realized that was not the intended action.

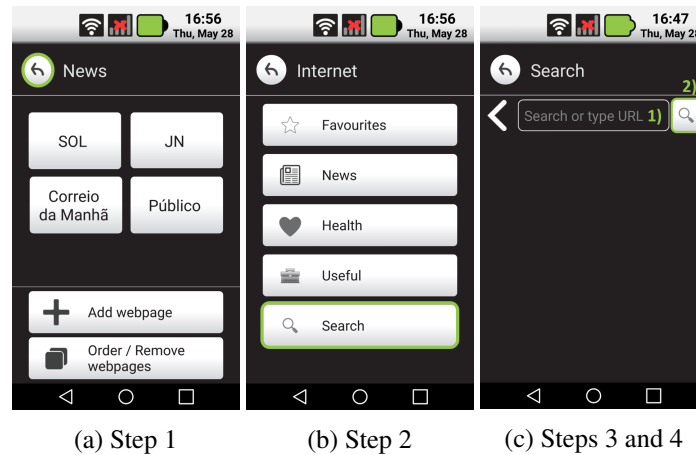


Figure 6.6: Ideal flow for performing task 5

6.1.1.6 Task 6: Searching for a specific webpage

After completing the previous task, there was a need to evaluate if seniors could really understand the use of the address bar, i.e., if they could identify that field when the "Search or type URL" hint was hidden. Thus, they were asked to make a new search (in this case, go to the webpage "youtube.com"). Again, the ideal flow graphical representation can be seen in Figure 6.7.

This task was successfully performed by nine of the ten test participants. The other one closed search activity and started a new search, instead of typing the URL in the address bar.

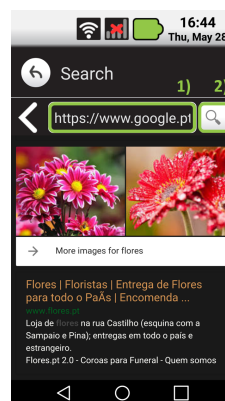


Figure 6.7: Ideal flow for performing task 6

6.1.1.7 Task 7: Going back in the navigation history

Task number 7 aimed at finding out if the elderly could identify the feature that allows one to go back in the browser navigation history. This can be achieved by clicking on the white arrow at the

left of the address bar (Figure 6.8).

Eight of the ten test participants were able to identify the back arrow and its functionality. As for the other two participants, one of them rewrote the search term in the address bar and the other closed the search activity, reopened it and typed in the search term in the address bar. The last was the same participant that was not able to complete task number 6 within the expected number of steps.

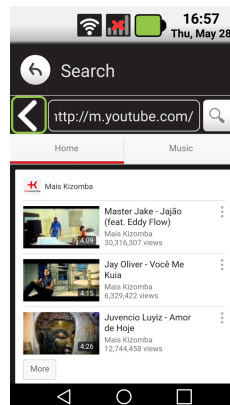


Figure 6.8: Ideal flow for performing task 7

6.1.1.8 Task 8: Going back to previous screen

After performing task number 7, participants were asked to go back to the application main screen, to see if they could understand the difference between the back arrow to navigate between application screens and the back arrow to navigate on browsing history.

All seniors have accomplished this task, showing no difficulties.

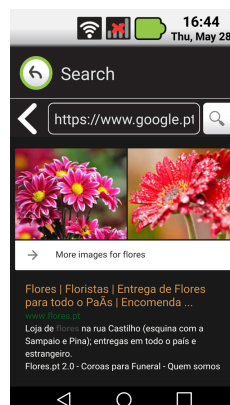


Figure 6.9: Ideal flow for performing task 8

6.1.1.9 Task 9: Opening a webpage from the most visited webpages list

Finally, task 9 aimed at identifying if seniors could identify the most visited webpages list, showed on the "Search" screen. Thus, they were asked to open search again, and open "Público" webpage, which was the first webpage on the list, as can be seen in Figure 6.10.

This task was easily performed by all participants.

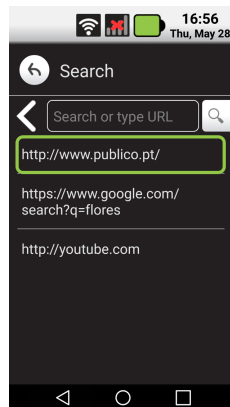


Figure 6.10: Ideal flow for performing task 9

6.1.2 Results

To evaluate the usability of the application, three metrics were used: effectiveness, efficiency and satisfaction.

Effectiveness was measured through task completion rate, frequency of errors and deviations. As can be seen in Figure 6.11, the average number of deviations from the expected number of steps to complete the tasks was very small, which suggests that the application is, indeed, senior-friendly. Frequency of errors was also very low, indicating that the system is effective.

On the other hand, efficiency was assessed by the mean time to complete the task, which, in general, met the estimated time for each task. Therefore, it can also be considered that the application is efficient.

Finally, after completing the tasks, participants were asked to answer a small questionnaire, in order to evaluate their experience and satisfaction while using the application. Using a scale from 1 ("strongly disagree") to 5 ("strongly agree"), they classified the following statements:

1. I found the application easy to use.
2. I felt confident while using the application.
3. I found it easy to learn how to use the application.
4. I would like to use this application again.

Figure 6.12 displays the results obtained.

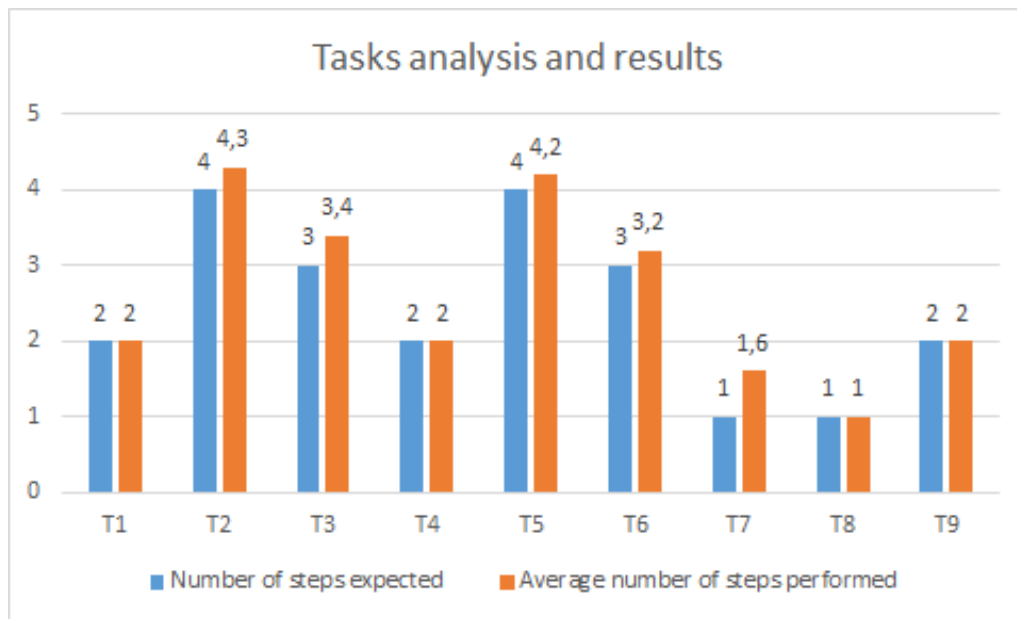


Figure 6.11: Comparison between the number of expected steps to complete each task and the number of performed steps by participants

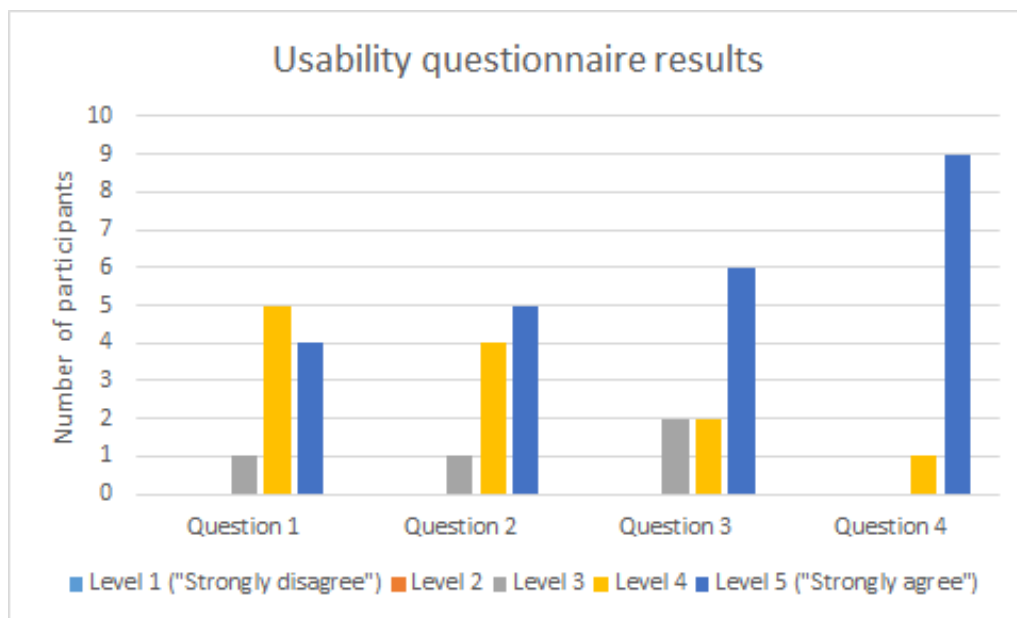


Figure 6.12: Usability questionnaires results (level 1: strongly disagree; level 5: strongly agree)

These results are promising, since they showed that participants, in general, had a nice experience while using the application and would like to use it again.

6.2 Summary

This chapter described the usability tests of the final application prototype. These tests were made with the target users (older adults), revealing promising results. All requested tasks were, in general, performed with no effort, proving that the developed application has, indeed, a senior-friendly design. Besides, all the webpage customizations were widely approved and appreciated by the elderly.

With that said, it can be concluded that the goals of this project were fulfilled, although further improvements can (and should) always be done.

The next chapter details the main conclusions about this work, as well as future work possibilities.

Evaluation and validation

Chapter 7

Conclusion and future work

The work in this thesis aimed at designing, developing and evaluating an Android mobile application that consists of a Web browser for older adults, focusing on their needs. This was done through an in-depth literature review on older adults' characteristics and behaviours towards Web interaction, as well as on guidelines for designing for older people, in order to find possible modifications and improvements regarding senior user interaction with current technologies.

7.1 Methodology

In order to validate the solution and get feedback from users, both low-fidelity prototypes (using the Wizard of Oz technique) and high-fidelity prototypes were developed and tested with a group of elders, at a social centre. This was important to create a fast-paced cycle of continuous development and testing, thus increasing the received feedback and, consequently, the overall quality of the system. Given these premises, the development of this project followed a UCD methodology, which puts the user at the centre of the design process.

Interviews were made to understand the seniors' mobile device and Web usage patterns, as well as finding out if there were any functional impairments that could compromise Web interaction. Some terminology tests were made, so the most understandable name for each option could be found and used. Card sorting was also used to select the most appropriate icons for each option. Finally, the seniors were asked to perform some tasks, in order to test the application's usability.

The application design aimed at being simplistic and easy to learn and understand, especially because most elderly people had little to no experience with smartphones and tablets. Central to this ideology was the need for simple screens, including only essential functionality for a mobile Web browser and following a set of layout rules to ensure consistency across the system.

With these needs in mind, every application screen is divided into three main components: at the top, there is a header with a concise title informing where in the application the user is and

what can be done in that screen; in the middle of the screen is the main content; at the bottom are the buttons that represent the possible actions the user can perform. Also, big buttons and large font sizes are favoured, so users have no difficulties reading or tapping the options.

In theory, designing a senior-oriented application improves Web interaction for older people. However, many websites do not adhere to the accessibility guidelines for designing Web applications, or if they do, some assume that users are familiar with the technology. Thus, Web interaction for elder users could be improved if webpage presentation was also personalized to meet their necessities.

Considering these guidelines, EzNav aimed at improving Web browsing experience, by simplifying webpages' content and adapting the browser to fit users' needs. The customizations made consist of implementing negative polarity in every webpage and increasing spacing between paragraphs, by adapting the webpage CSS, and removing ads, which is achieved by blocking calls to common publicity sources. Besides, users can enlarge images by long pressing on them. In addition, the most frequently webpages visited by users are recorded in a list, allowing the application to adapt to each user's habits, such as when visiting the "Search" screen.

7.2 Contribution

The expected contribution of this work is that the elderly can learn to confidently and easily surf the Web, and consequently realize its vast benefits, namely fighting loneliness, keeping their minds "busy" and staying in touch with family and friends, thus promoting active, independent ageing and bringing happiness to older people.

As can be seen in chapter 6, results from the final usability testing proved promising, with all test participants performing all tasks, with no effort. Besides, seniors, in general, felt the application was easy to use and all of them would like to use it again, which shows great acceptance and interest in the application.

Given these results, there are reasons to believe that the developed application, can, in fact, meet the expected benefits, with all the development goals mentioned in chapter 1 being, in general, fulfilled. However, further improvements can always be done, as detailed in the next section.

Besides the work conducted, it is also important to note the writing of a paper, with some of the major findings of this project, submitted for acceptance at the CHIItaly 2015 conference, that can be found in Appendix H.

7.3 Future work

Despite preliminary results having already indicated that the application fulfils the various aspects of usability as well as its great acceptance among the elderly, there are still some improvements to be done and features to add.

Conclusion and future work

Future work can be done, regarding the webpages customization, trying to make all different webpages become as coherent as possible among them, and following Web design guidelines for older people, thus facilitating Web interaction for this type of users. For instance, better reading experience could be provided to users, by stripping out unnecessary page elements down to the main content of a webpage and presenting it in a clean and simple format, allowing them to focus on the articles, news or any other content they are interested in reading about, without getting distracted by all the clutter and noise that is found in many webpages. Another possibility is to implement some mechanism that allows users to select what kind of transformations they want to be done to webpages. The implementation of advanced settings could also be done, for example, allowing the seniors or their caregivers to create new categories or block certain webpages.

An interesting aspect that is yet to be explored is the implementation of machine learning algorithms, so the browser can self-adapt to each individual's needs, for example, by suggesting webpages according to a user's browsing patterns.

Finally, it is important to test the application with a larger number of older adults and, ideally, for longer periods of time, to corroborate the theory that the application really helps seniors to learn how to surf the Web and that it brings happiness to their daily lives.

Conclusion and future work

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REFERENCES

Appendix A

Web design guidelines for older people

Following, you can see Kurniawan and Zaphiris [KZ05] 38 guidelines, grouped by categories' headers:

H1. Target Design

H1.1. Provide larger targets

H1.2. There should be clear confirmation of target capture, which should be visible to older adults who should not be expected to detect small changes

H1.3. Older adult should not be expected to double click

H2. Use of Graphics

H2.1. Graphics should be relevant and not for decoration. No animation should be present

H2.2. Images should have alt tags

H2.3. Icons should be simple and meaningful

H3. Navigation

H3.1. Extra and bolder navigation cues should be provided

H3.2. Clear navigation should be provided

H3.3. Provide location of the current page

H3.4. Avoid pull down menus

H3.5. Do not use a deep hierarchy and group information into meaningful categories

H4. Browser Window Features

H4.1. Avoid scroll bars

H4.2. Provide only one open window e.g., pop-up/ animated advertisements or multiple overlapping windows should be avoided

H5. Content Layout Design

H5.1. Language should be simple and clear

H5.2. Avoid irrelevant information on the screen

Web design guidelines for older people

H5.3.Important information should be highlighted

H5.4.Information should be concentrated mainly in the centre

H5.5.Screen layout, navigation and terminology used should be simple, clear and consistent

H6. Links

H6.1.There should be differentiation between visited and unvisited links

H6.2.Links should be clearly named and no link with the same name should go to a different page

H6.3.Links should be in a bulleted list and not tightly clustered

H7. User Cognitive Design

H7.1.Provide ample time to read information

H7.2.Reduce the demand on working memory by supporting recognition rather than recall and provide fewer choices to the user

H8. Use of Colour and Background

H8.1.Colours should be used conservatively

H8.2.Blue and green tones should be avoided

H8.3.Background screens should not be pure white or change rapidly in brightness between screens. Also, a high contrast between the foreground and background should exist, for example, coloured text on coloured backgrounds should be avoided.

H8.4.Content should not all be in colour alone (colour here is denoted by all colours other than black and white)

H9. Text Design

H9.1.Avoid moving text

H9.2.Text should be left justified and text lines should be short in length

H9.3.There should be spacing between the lines

H9.4.Main body of the text should be in sentence case and not all capital letters

H9.5.Text should have clear large headings

H9.6.Use san serif type font i.e., Helvetica, Arial of 12-14 point size. Avoid other fancy font types.

H10. Search Engine

H10.1.Search engines should cater for spelling errors

H11. User Feedback & Support

H11.1.Provide a site map

H11.2.An online help tutorial should be provided

H11.3.Support user control and freedom

Web design guidelines for older people

H11.4. Error messages should be simple and easy to follow

Appendix B

Informed consent

CONSENTIMENTO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

A Associação Fraunhofer Portugal Research faz trabalho de investigação destinado a encontrar soluções que promovam o bem-estar da população.

No âmbito do projecto «A Web browser for the elderly», estamos a desenvolver um navegador Web, para Android, destinado à população sénior, com o objectivo de facilitar a interacção deste tipo de utilizadores com a Web.

Para o estudo, iremos proceder à recolha de dados sociodemográficos e de saúde. Para esta recolha fazemos questionários, entrevistas, recolhemos dados de som, vídeo ou fotografia e fazemos testes de usabilidade usando protótipos em papel, ou então em *smartphones/tablets* já disponíveis no mercado. Os testes consistem em avaliar a usabilidade da aplicação, para ver se é necessário fazer algum melhoramento, de modo a que as necessidades dos referidos utilizadores sejam satisfeitas.

Gostaríamos de contar com a sua participação. A participação não envolve qualquer prejuízo ou dano material e não haverá lugar a qualquer pagamento. Os dados recolhidos são confidenciais. A Associação Fraunhofer Portugal Research tomará todas as medidas necessárias à salvaguarda e protecção dos dados recolhidos por forma a evitar que venham a ser acedidos por terceiros não autorizados.

A sua participação é voluntária, podendo em qualquer altura cessá-la sem qualquer tipo de consequência.

Agradecemos muito o seu contributo, fundamental para a nossa investigação!

O participante:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando que apenas serão utilizados para investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Autorizo a comunicação de dados de forma anónima a outras entidades que estabeleçam parceria com a Associação Fraunhofer Portugal Research para fins académicos e de investigação científica.

Nome do participante: _____

Assinatura do participante: _____

Data ____ / ____ / ____

Investigador responsável:

Nome: Renato Oliveira

Telefone: 220 408 300

E-mail: renato.oliveira@fraunhofer.pt

Appendix C

Interview Guide

C.1 English version

C.1.1 Goals of the interview

- Understand how seniors use the Web
- Understand the main difficulties that seniors face, while using the Web

C.1.2 Introduction

Hi, my name is Ana and I am finishing my Master in Informatics and Computer Engineering. My final project consists in the design and development of a system that allows older people to surf the Web, in a easier and more intuitive way.

For that, I need your help to understand the needs and characteristics of people from your age group. I would like to ask you some simple questions that will help me understand how I should develop the project. This session will take no more than 30 minutes of your time.

Before we start, I just want to make it clear that you are not being tested. I am here only to understand how I can design a system that is suitable to older people characteristics.

C.1.3 Questions

1. What is your name?
2. When were you born?
3. Did you study? For how long?
4. Do you use the Web? (Never / Rarely / Sometimes / Often)
 - If not, why?
 - If so, what are the pages you like to visit the most?

Interview Guide

5. Do you use touchscreen devices (tablet/smartphone)? (Never / Rarely / Sometimes / Often)

If so:

- Do you find it difficult to press buttons, links or fill out camps? Why? (too small, difficult to identify, etc)
 - Do you have any other difficulty, while using touchscreen devices?
6. Do you have vision problems? What about other impairments that makes it more difficult to interact with technologies? (e.g.: motor or cognitive impairments)
 7. When you think about surfing the Web, do you feel any fears related to it? (fear of damaging something, fear of providing personal data, etc)
 8. If you used the Web, what kind of information would you like to obtain? (news, weather, videos, etc)

C.2 Portuguese version

C.2.1 Objectivos da entrevista

- Perceber como os idosos utilizam a Web
- Perceber quais as principais dificuldades que os idosos enfrentam ao navegar na Web

C.2.2 Introdução/Enquadramento

Olá, o meu nome é Ana e estou no último ano do meu curso: Engenharia Informática. O meu projecto de fim de curso consiste em desenhar e desenvolver um sistema que permita às pessoas mais velhas navegar na Web, de forma mais fácil e intuitiva.

Para isso, preciso da sua ajuda para perceber as necessidades e características das pessoas da sua faixa etária. O que lhe pedia era que respondesse a algumas perguntas simples que me vão ajudar a saber como desenvolver o projecto. Esta sessão não lhe deverá demorar mais do que 30 minutos.

Antes de começarmos, queria só deixar bem claro que não é o senhor(a) que está a ser testado. Estou aqui apenas para perceber como é que posso desenhar um sistema adequado às características das pessoas mais velhas.

C.2.3 Questões

1. Como se chama?
2. Qual a sua data de nascimento?
3. Estudou? Até que ano?

Interview Guide

4. Costuma utilizar a internet? (Nunca / Raramente / Algumas vezes / Frequentemente)
 - Se não, porquê?
 - Se sim, quais são as páginas que mais gosta de visitar?
5. Costuma utilizar aparelhos com ecrã táctil (ex: tablets/smartphones)? (Nunca / Raramente / Algumas vezes / Frequentemente)
 - Se sim:
 - Sente dificuldade em carregar nos botões, hiperligações ou preencher campos? Porquê? (muito pequeno, difícil de identificar, etc)
 - Sente outro tipo de dificuldades?
6. Tem problemas de visão? E outro tipo de problemas que afectem o uso de tecnologias? (dificuldades motoras, cognitivas, etc)
7. Quando pensa em navegar na Web, sente algum medo em relação a isso? (medo de fornecer dados pessoais, estragar alguma coisa, etc)
8. Se utilizasse a Web, qual o tipo de informação que mais gostaria de obter? (notícias, viagens, tempo, vídeos, etc)

Interview Guide

Appendix D

ISO/IEC 25062 Usability Test Protocol



Fraunhofer

PORTUGAL

RESEARCH CENTER FOR ASSISTIVE INFORMATION AND COMMUNICATION SOLUTIONS

ISO/IEC 25062 Usability Test Protocol - *EzNav*

2015

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1. Users

For this evaluation, it is expected to recruit about 10 participants aged 60 and older, with little or no prior Internet experience. However, it is probable that some of them use the Internet frequently, which is not a problem for the tests; in fact, these participants also contribute for the evaluation.

2. Context of product use in the test

2.1. Test facility

The evaluation will take place at “Centro de Dia do Bonfim”, a social centre located in Porto. This location was chosen for being the most convenient for the participants because it is where they usually spend most of their day. Besides, since the application has been designed to be used in the participants' natural environment, this is almost a perfect place for the tests.

2.2. Display devices

The evaluation of EzNav application will be performed on a LG G3 with a 5.5" Quad HD (2560X1440) IPS screen and on a Samsung Galaxy Tab S with a 10.5" WQXGA (2560x1600) screen, both in standard colour mode and automatic brightness.

3. Test procedure

3.1. Participant general instructions

EzNav is an Android mobile application being developed under a master thesis at Faculdade de Engenharia - Universidade do Porto, in collaboration with Associação Fraunhofer Portugal Research.

Older people tend to be reticent about using the Web because they have some fears, such as damaging the machine, doing something wrong or not knowing what to do in a given situation. Besides, as people get older, some difficulties arise, such as vision, cognitive and motor impairments, that may be an obstacle for Web interaction.

The proposed mobile application aims at designing and developing a system that allows older people to surf the Web, in an easier and more intuitive way. For that, I need your help to evaluate the usability of this product. I will ask you to perform some tasks using the application prototype. Feel free to ask for ask me for assistance, if needed, as well as voice your opinions regarding any aspect of the application. Remember that we are testing the application and not the user, and there are no right or wrong ways to perform a task. We just want you honest feedback and opinion, so feel free to point out something you don't understand or don't like. This session should not take more than 30 minutes of your time. In the

end, I will ask you to answer a small and quick questionnaire, to evaluate your experience with the application.

After the test and questionnaire:

Is there any questions or comments you want to make?

Thank you very much for your contribution, your opinion is very valuable to us.

3.2. Participant task instructions

The participants will be asked to perform the following tasks:

Task 1: Starting from the application initial screen, open "Público" news webpage.

Ideal flow: [Choose "News" -> Choose "Público"]

Task 2: Go back and add a webpage to "News" category, with title "SOL" and address "sol.pt"

Ideal flow: [Go back to "News" -> Choose "Add webpage" -> Fill in the fields -> Choose "Confirm" -> Choose "OK"]

Task 3: Delete "Diário de Notícias" webpage.

Ideal flow: [Choose "Order / Remove webpages" -> Click the delete (trash bin symbol) button -> Choose "Yes"]

Task 4: Order webpages and make SOL the first one.

Ideal flow: [Press the drag symbol, at the right of "SOL" and drag it to the first position -> Choose "Confirm"]

Task 5: Go back and search for anything you want.

Ideal flow: [Go back to the main screen -> Choose "Search" -> Type a query or a URL on "Search or type URL" field -> Click on the search button (at the right of the address bar or on the soft keyboard)]

Task 6: Go to "youtube.com".

Ideal flow: [Click on the address bar -> Type in the URL -> Click on the search button (at the right of the address bar or on the soft keyboard)]

Task 7: Go back to the previous webpage.

Ideal flow: [Click on the back button (white arrow on the left of the field)]

Task 8: Go back to home screen.

Ideal flow: [Click on the back button, at the top, next to "Search"]

Task 9: Open search and open "Público" again.

Ideal flow: [Choose "Search" -> Choose "Público" from the most visited webpages list]

After completing the tasks, participants must be given a usability questionnaire (see appendix 5.1.)

4. Performance and satisfaction metrics

4.1. Criteria and measurements

To evaluate the usability of the application, three metrics will be used: effectiveness, efficiency and satisfaction.

4.2. Metrics for effectiveness, efficiency and satisfaction

Effectiveness - Effectiveness relates the goals of using the product to the accuracy and completeness with which these goals can be achieved. To measure the effectiveness of this application, the following parameters will be used: task completion rate (using the number of steps that form the ideal flow), frequency of errors (performance of an action that does not contribute to task completion), and deviations (alternative flows to the completion of the task).

Efficiency - Efficiency relates the level of effectiveness achieved to the quantity of resources expended. In this case, it will be assessed by the mean time take to complete the task.

Satisfaction - Describes a user's subjective response when using the product. This will be measured through the usability questionnaire administered after the test. In addition, all comments made by the participants during the tests will be registered.

5. Appendices

5.1. Usability questionnaire

1. I found the application easy to use.

Strongly disagree

1	2	3	4	5
---	---	---	---	---

 Strongly agree

2. I felt confident while using the application.

Strongly disagree

1	2	3	4	5
---	---	---	---	---

 Strongly agree

3. I found it easy to learn how to use the system.

Strongly disagree

1	2	3	4	5
---	---	---	---	---

 Strongly agree

4. I would like to use this application again.

Strongly disagree

1	2	3	4	5
---	---	---	---	---

 Strongly agree

5.2. Participant general instructions (Portuguese translation)

EzNav é uma aplicação móvel para Android que está a ser desenvolvida no âmbito de uma tese de mestrado na Faculdade de Engenharia - Universidade do Porto, em colaboração com a Associação Fraunhofer Portugal Research.

As pessoas mais velhas tendem a ser reticentes no que toca à utilização da Web, porque têm alguns medos, tais como estragar o equipamento, fazer algo errado ou não saber o que fazer numa dada situação. Além disso, à medida que as pessoas envelhecem, surgem algumas dificuldades, como problemas de visão, dificuldades cognitivas e problemas motores, que podem ser um obstáculo para a interação Web.

A aplicação móvel proposta visa desenhar e desenvolver um sistema que permita às pessoas mais velhas navegarem na Web, de uma forma mais fácil e intuitiva. Para tal, preciso da sua ajuda para avaliar a usabilidade deste produto. Vou-lhe pedir que realize algumas tarefas, utilizando o protótipo da aplicação. Esteja à vontade para me perguntar alguma coisa que não perceba, bem como para expressar em voz alta as suas opiniões em relação a qualquer aspecto da aplicação. Quero apenas deixar bem claro que estamos a testar a aplicação e não o utilizador, pelo que não há formas correctas nem erradas de realizar uma tarefa. Queremos, simplesmente, a sua opinião honesta, por isso sinta-se à vontade para referir algo que não perceba ou não goste. Esta sessão não deve tomar-lhe mais do que 30 minutos do seu tempo. No fim, vou-lhe pedir para responder a um breve questionário, apenas para avaliar a sua experiência ao utilizar a aplicação.

Após o teste e o questionário:

Há alguma questão que queira colocar ou algum comentário que queira fazer?

Muito obrigada pela sua contribuição, a sua opinião é de grande valor para nós.

5.3. Participant task instructions (Portuguese translation)

Vai ser pedido aos participantes que realizem as seguintes tarefas:

Tarefa 1: A partir do ecrã inicial da aplicação, abra a página Web de notícias do "Público".

Fluxo ideal: [Escolher "Notícias" -> Escolher "Público"]

Tarefa 2: Volte para trás e adicione uma página à categoria "Notícias", com o título "SOL" e o endereço "sol.pt"

Fluxo ideal: [Voltar para "Notícias" -> Escolher "Adicionar página Web" -> Preencher os campos -> Escolher "Confirmar" -> Escolher "OK"]

Tarefa 3: Remova a página Web "Diário de Notícias".

Fluxo ideal: [Escolher "Ordenar / Remover páginas Web" -> Clicar no botão de apagar (símbolo de caixote do lixo) -> Escolher "Sim"]

Tarefa 4: Ordenar páginas Web e meter o SOL em primeiro lugar.

Fluxo ideal: [Pressionar o símbolo localizado à direita de "SOL" e arrastar para a primeira posição -> Escolher "Confirmar"]

Tarefa 5: Volte atrás e pesquise uma informação à sua escolha.

Fluxo ideal: [Voltar para o ecrã inicial -> Escolher "Pesquisa" -> Escrever um termo de pesquisa ou um URL -> Clicar no botão de pesquisa (lupa) – à direita da barra de endereços ou no teclado virtual]

Tarefa 6: Vá para a página "youtube.com".

Fluxo ideal: [Clicar na barra de endereços -> Escrever o URL -> Clicar no botão de pesquisa (lupa) - à direita da barra de endereços ou no teclado virtual]

Tarefa 7: Volte para a página anterior.

Fluxo ideal: [Clicar no botão de retroceder (seta branca junto à barra de endereços)]

Tarefa 8: Volte para o ecrã inicial da aplicação.

Fluxo ideal: [Clicar no botão para voltar, ao lado de "Pesquisa"]

Tarefa 9: Abra a pesquisa e volte a abrir o "Público".

Fluxo ideal: [Escolher "Pesquisa" -> Escolher "Público" na lista de páginas Web mais visitadas]

Após completarem as tarefas, os participantes devem receber o questionário, para avaliar a escala de usabilidade do sistema (ver anexo 5.1.)

5.4. Usability questionnaire (Portuguese translation)

1. Achei a aplicação fácil de usar.

Discordo completamente

1	2	3	4	5
---	---	---	---	---

Concordo completamente

2. Senti-me confiante ao usar a aplicação.

Discordo completamente

1	2	3	4	5
---	---	---	---	---

Concordo completamente

3. Achei fácil aprender como utilizar a aplicação.

Discordo completamente

1	2	3	4	5
---	---	---	---	---

Concordo completamente

4. Gostava de voltar a usar esta aplicação.

Discordo completamente

1	2	3	4	5
---	---	---	---	---

Concordo completamente

6. References

National Institute of Standards and Technology, *NISTIR 7432 – Common Industry Specification for Usability – Requirements*, 2007

Appendix E

Low-fidelity prototypes

E.1 Low-fidelity prototypes for smartphone - Portuguese version



Figure E.1: Application main interface (smartphone - PT)

Low-fidelity prototypes

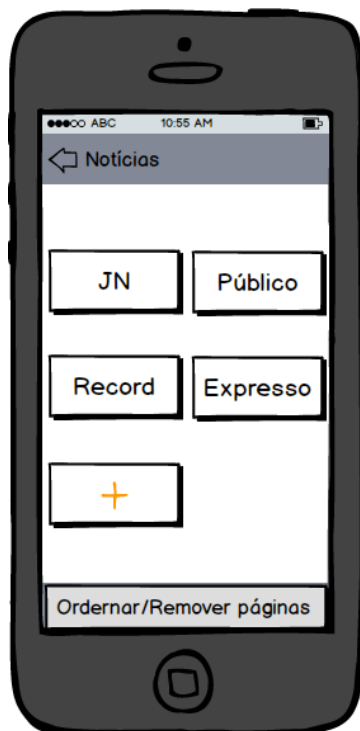


Figure E.2: Interface for the "News" category (smartphone - PT)

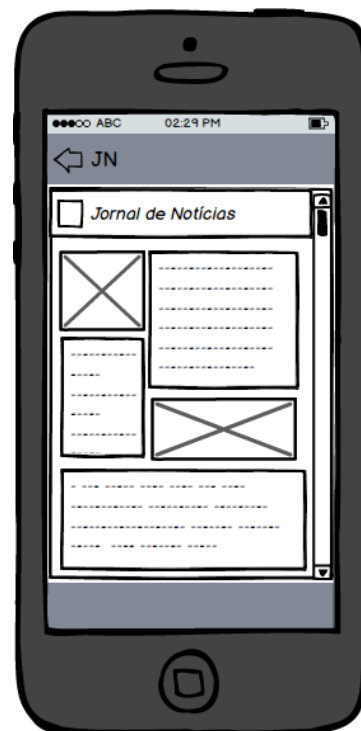


Figure E.3: Example of a "News" webpage (smartphone - PT)

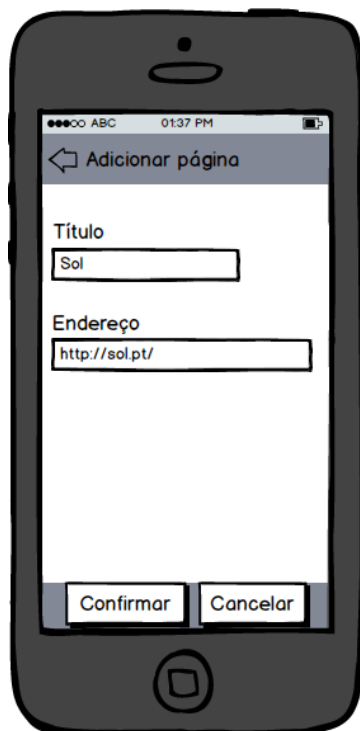


Figure E.4: Interface for adding a new webpage to a category (smartphone - PT)

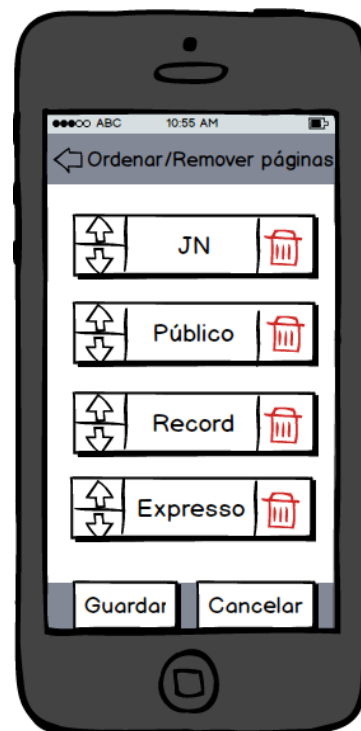


Figure E.5: Interface for ordering and removing webpages from a category (smartphone - PT)

Low-fidelity prototypes

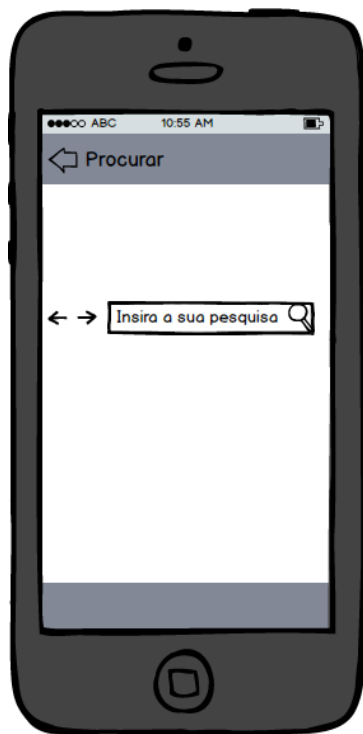


Figure E.6: Interface for the search functionality (smartphone - PT)



Figure E.7: Example of search result (smartphone - PT)

E.2 Low-fidelity prototypes for tablet - English version

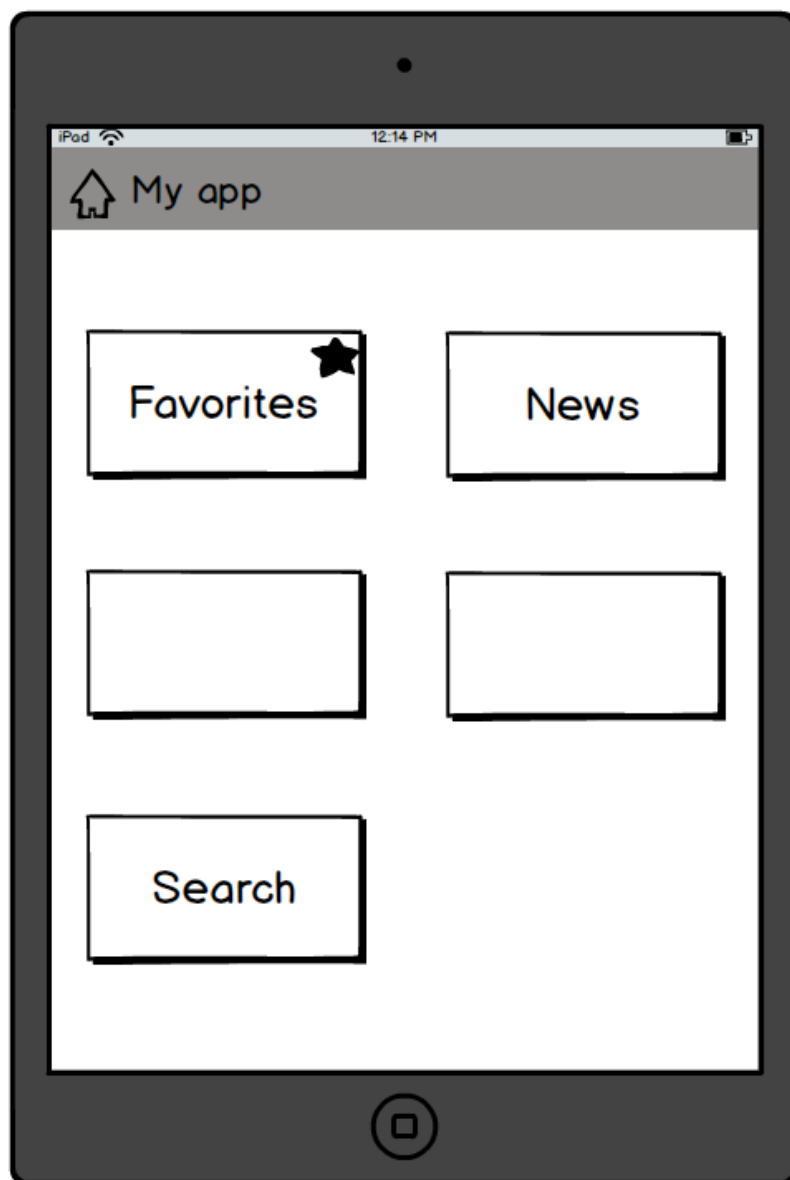


Figure E.8: Application main interface (tablet)

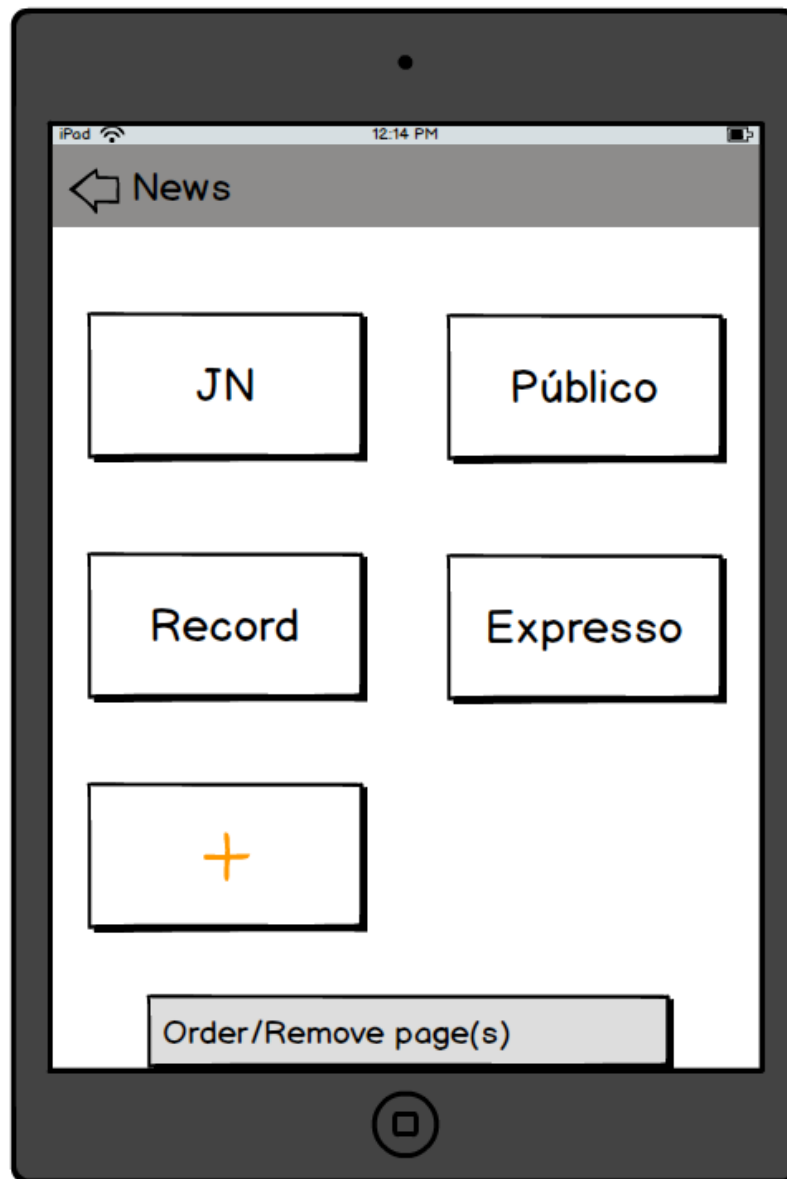


Figure E.9: Interface for the "News" category (tablet)

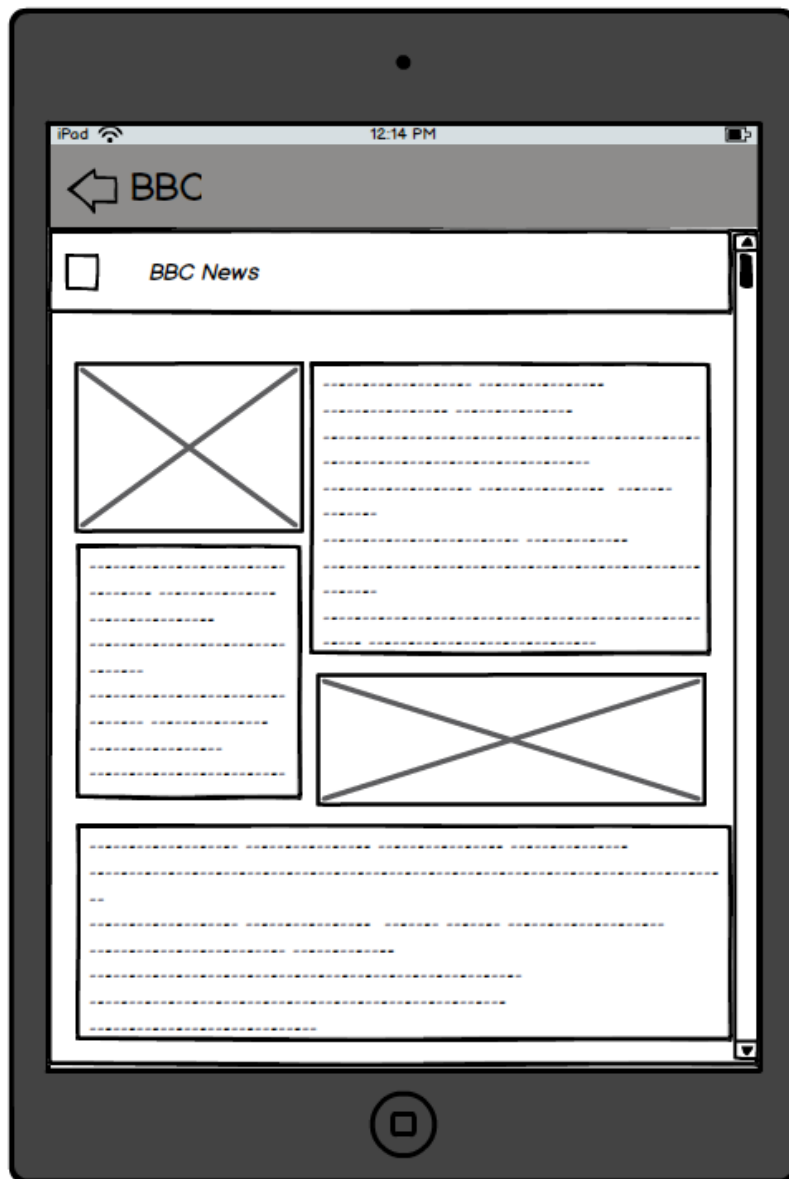


Figure E.10: Example of a "News" webpage (tablet)

iPad 12:14 PM

← Add page

Title
BBC

Address
http://www.bbc.com/news

✓ Confirm X Cancel

Figure E.11: Interface for adding a new webpage (tablet)

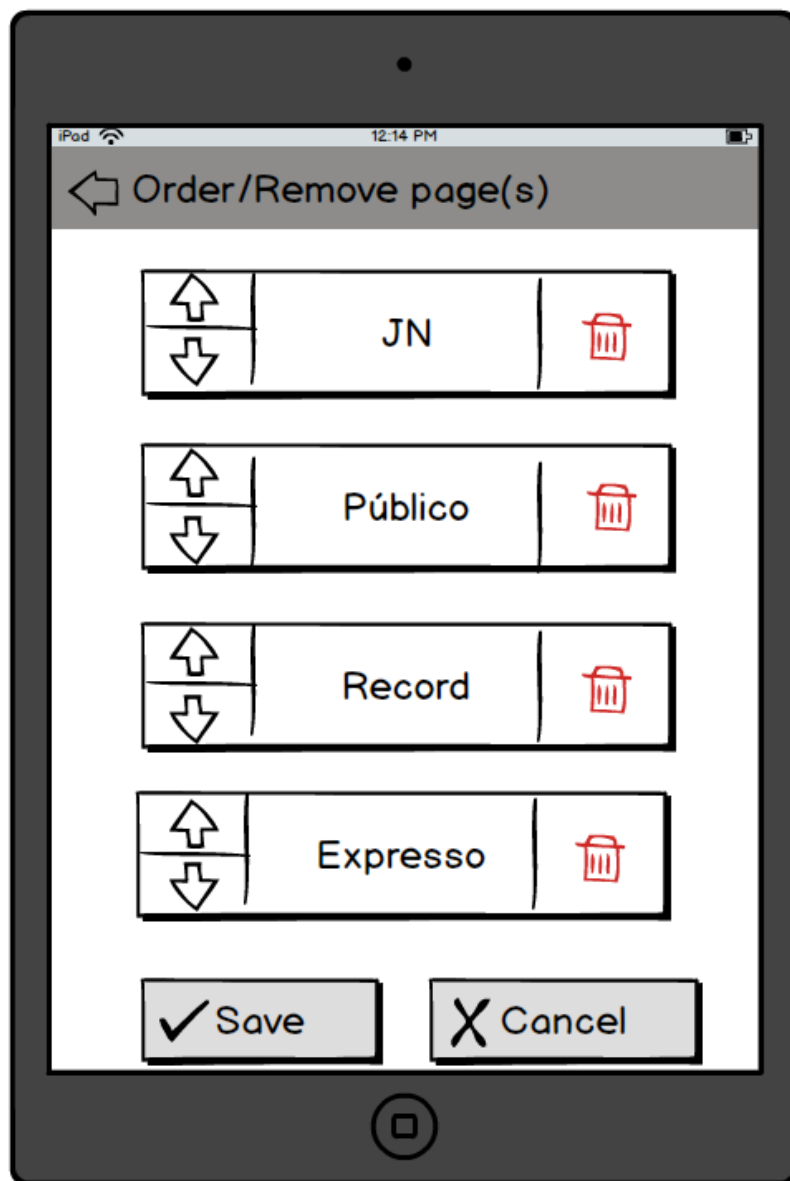


Figure E.12: Interface for ordering and removing webpages from a category (tablet)

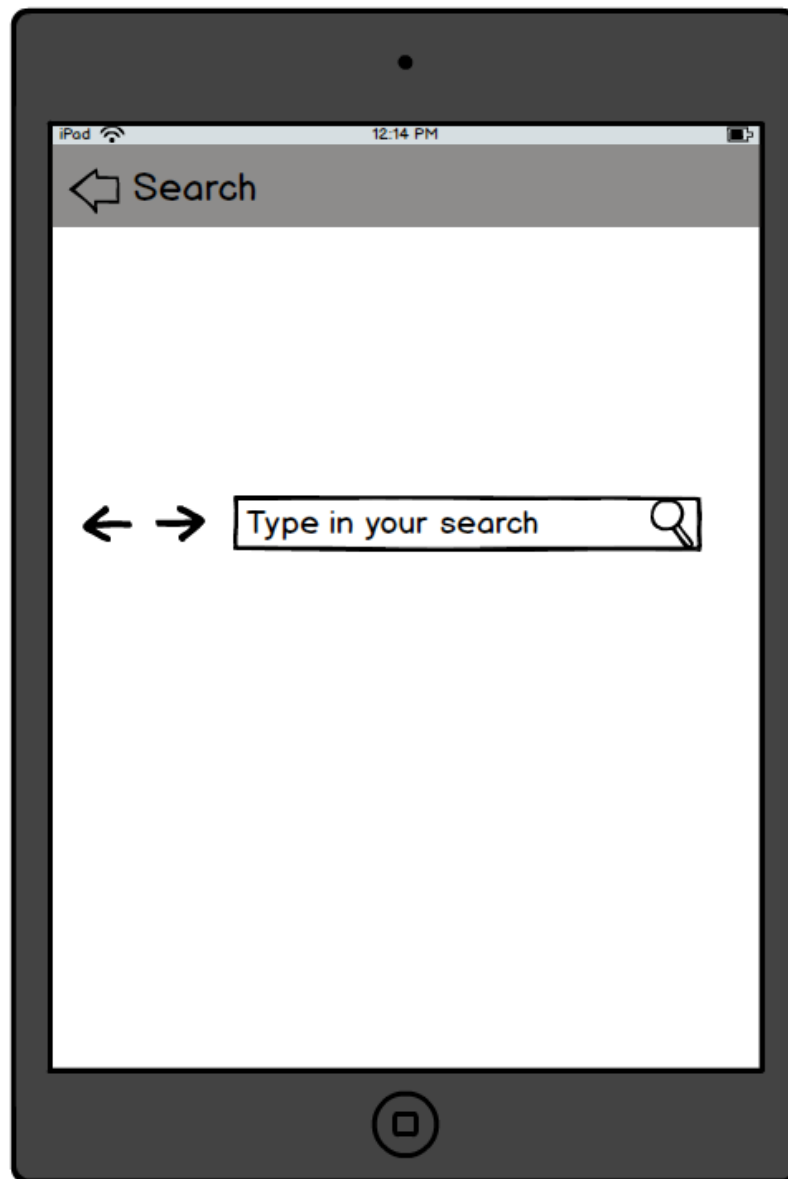


Figure E.13: Interface for the search functionality (tablet)

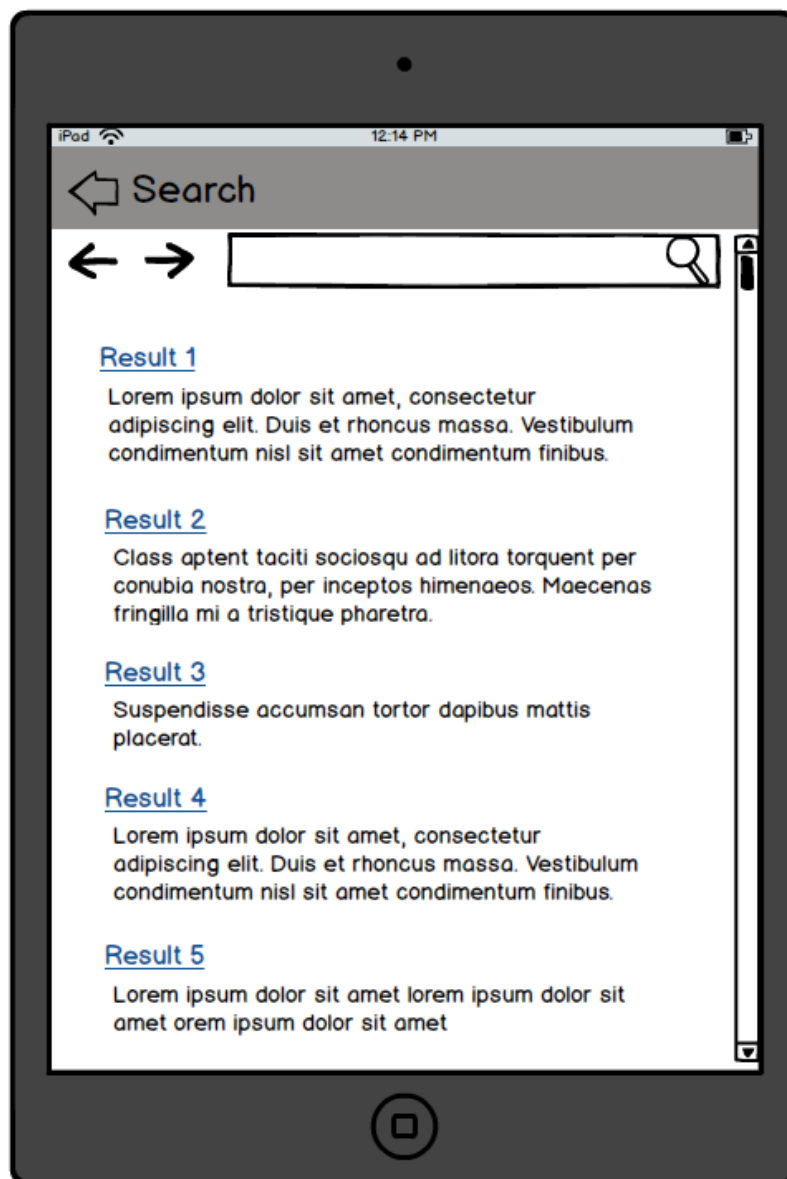


Figure E.14: Example of search results (tablet)

E.3 Low-fidelity prototypes for tablet - Portuguese version

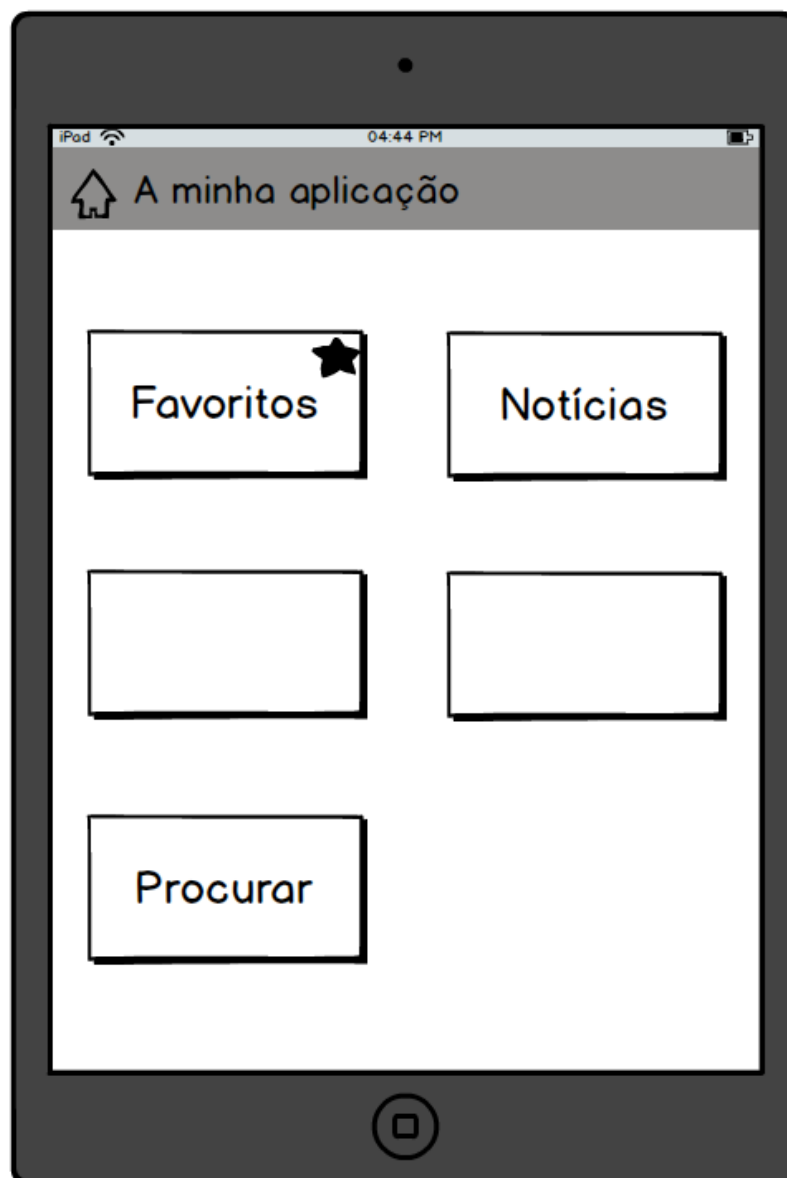


Figure E.15: Application main interface (tablet - PT)

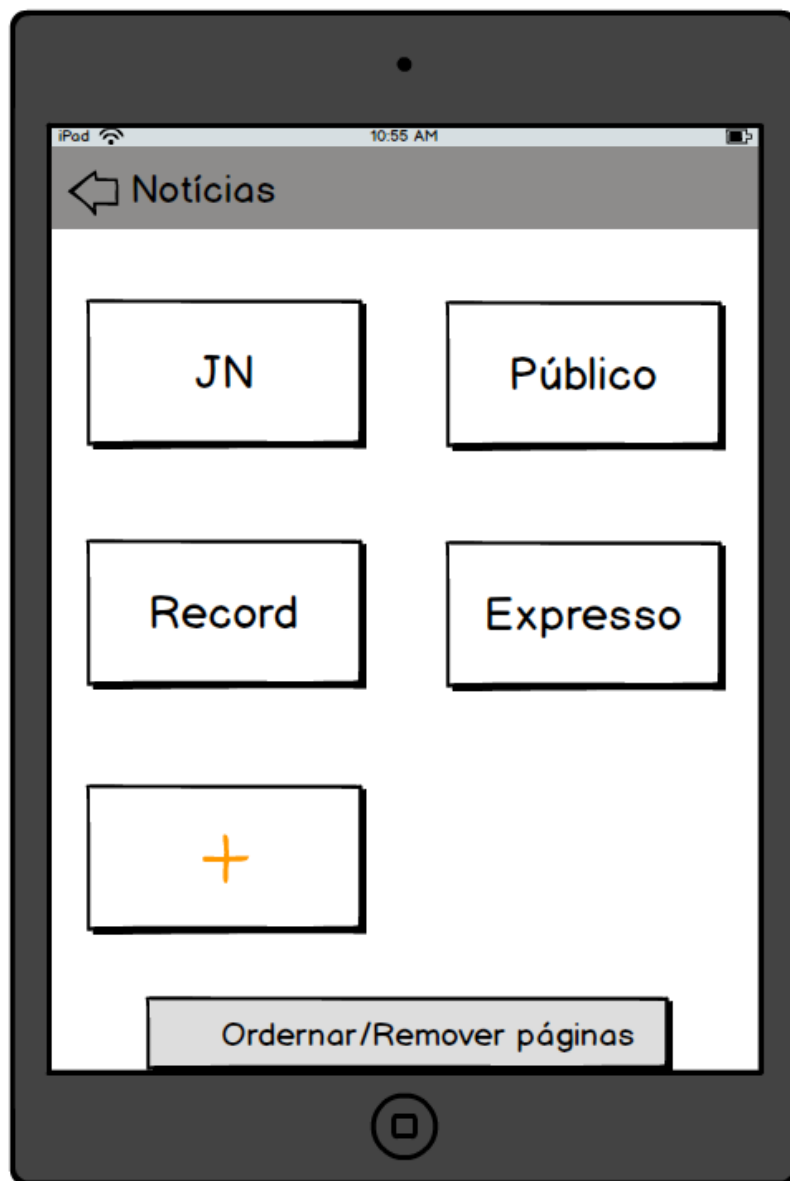


Figure E.16: Interface for the "News" category (tablet - PT)

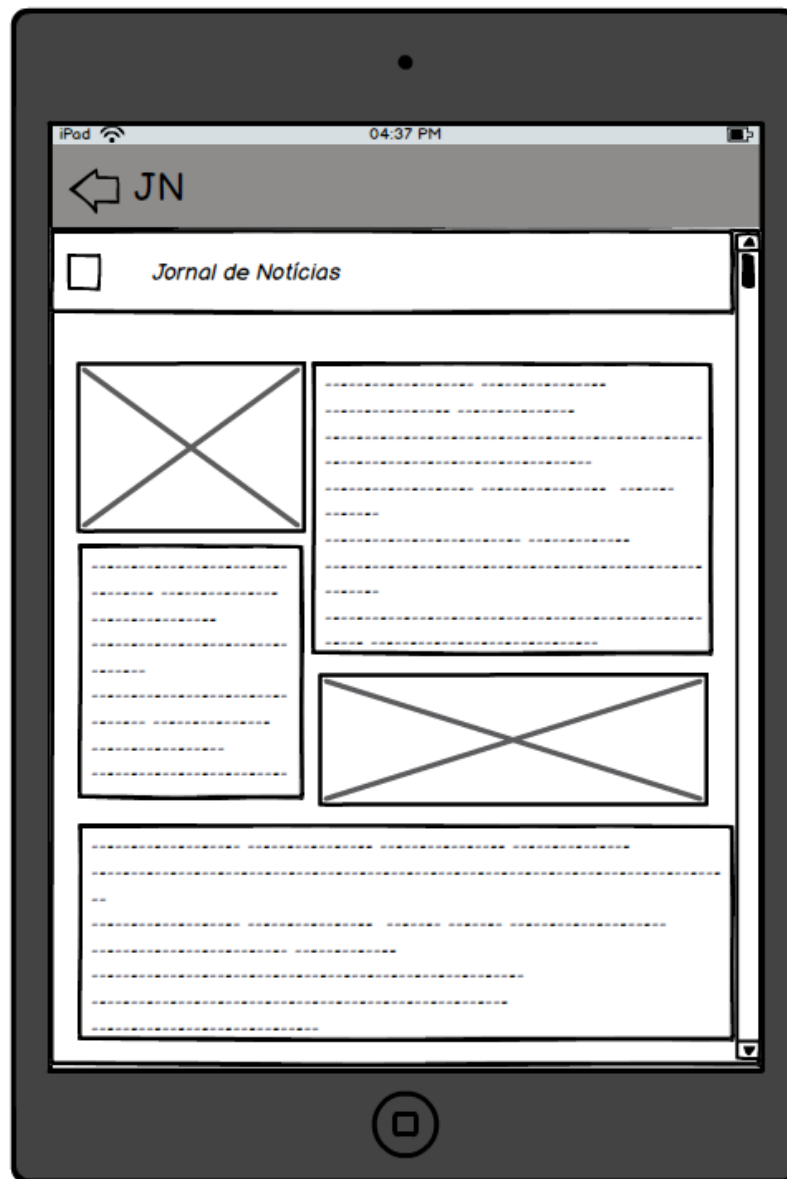


Figure E.17: Example of a "News" webpage (tablet - PT)

The image shows a low-fidelity prototype of a tablet interface. The screen is framed by a dark grey border representing the tablet. At the top, a status bar displays 'iPod', a signal strength icon, the time '06:22 PM', and a battery level icon. Below the status bar is a grey header bar with a back arrow icon and the text 'Adicionar página'. The main content area is white and contains two text input fields. The first field is labeled 'Título' and contains the text 'Sol'. The second field is labeled 'Endereço' and contains the text 'http://sol.pt/'. At the bottom of the screen, there are two buttons: 'Confirmar' with a checkmark icon and 'Cancelar' with an 'X' icon. A circular home button is visible at the very bottom of the tablet frame.

Figure E.18: Interface for adding a new webpage to a category (tablet - PT)

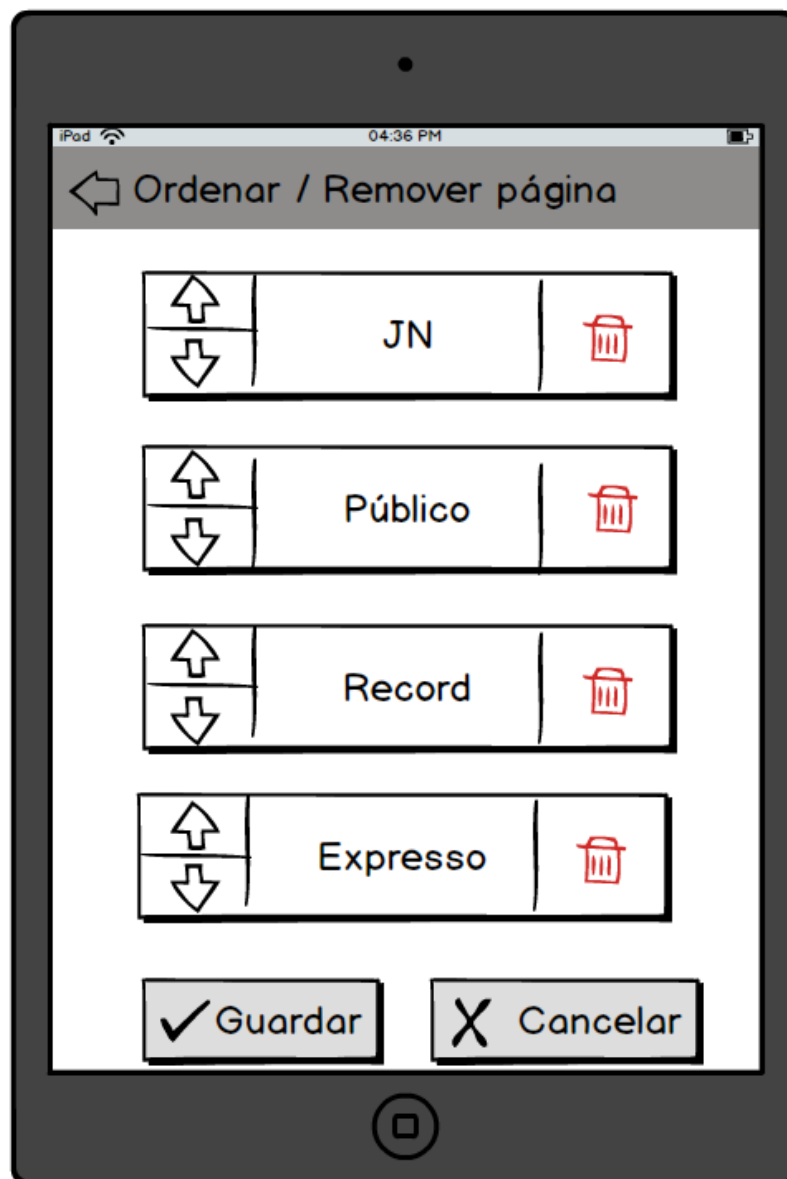


Figure E.19: Interface for ordering and removing webpages from a category (tablet - PT)

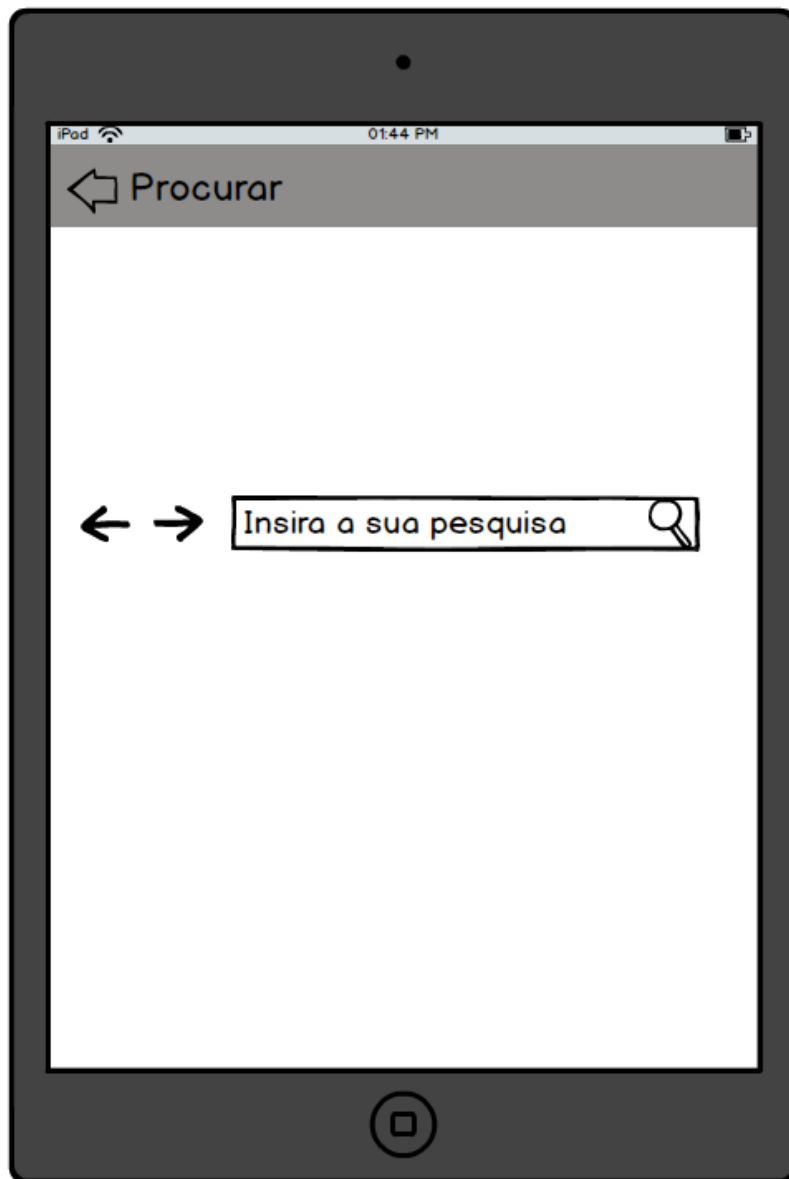


Figure E.20: Interface for the search functionality (tablet - PT)

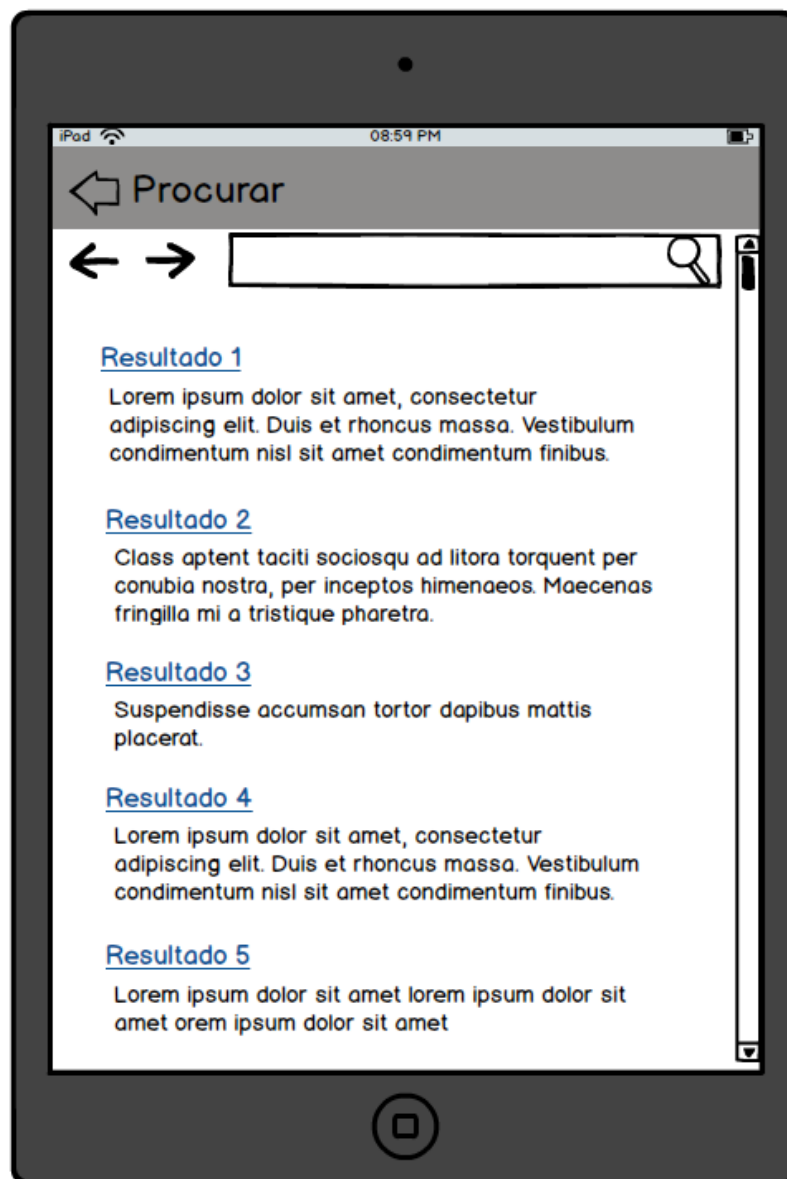


Figure E.21: Example of search result (tablet - PT)

Low-fidelity prototypes

Appendix F

Final prototypes

F.1 Application final prototypes for the smartphone - Portuguese version

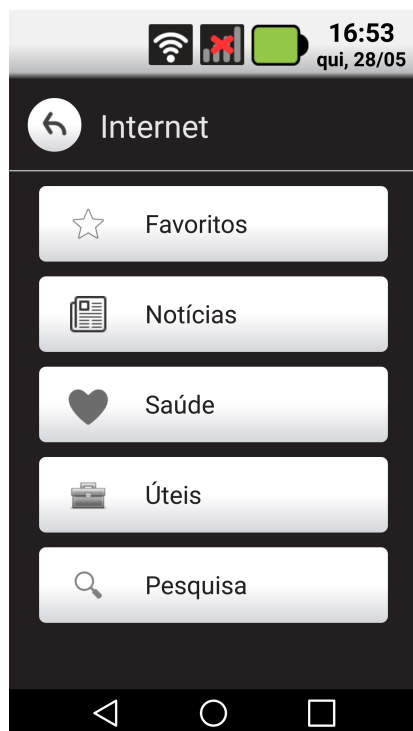


Figure F.1: Application main screen (smartphone - PT)

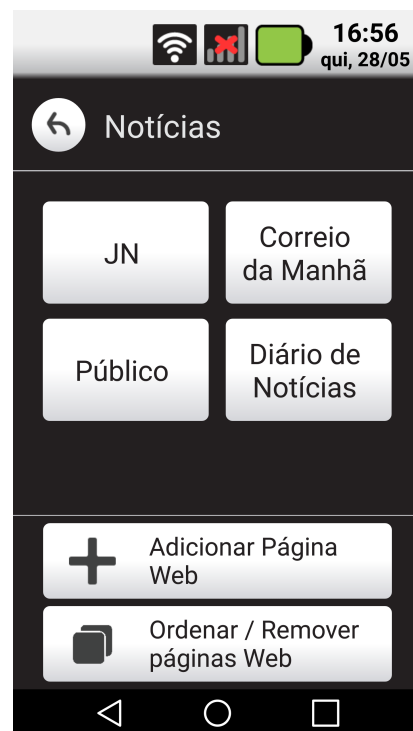


Figure F.2: Screen that shows the webpages inside a category - in this case, news (smartphone - PT)

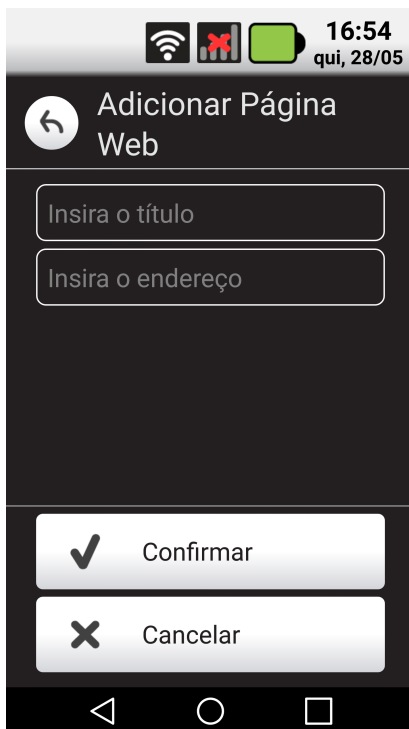


Figure F.3: Screen for adding a webpage to a category (smartphone - PT)



Figure F.4: Screen for ordering or removing a webpage within a category (smartphone - PT)



Figure F.5: Screen for searching for information on the Web (smartphone - PT)



Figure F.6: Custom error page (smartphone - PT)

F.2 Application final prototypes for the tablet - English version

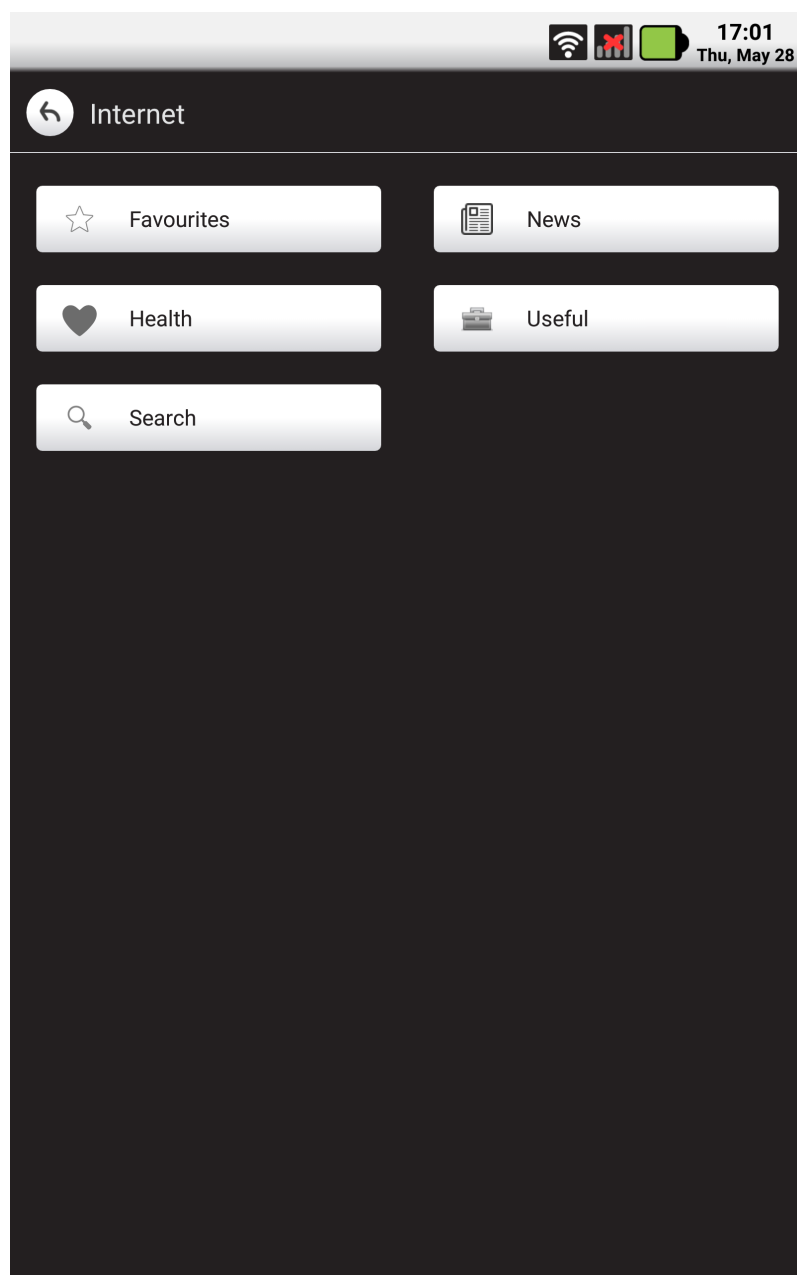


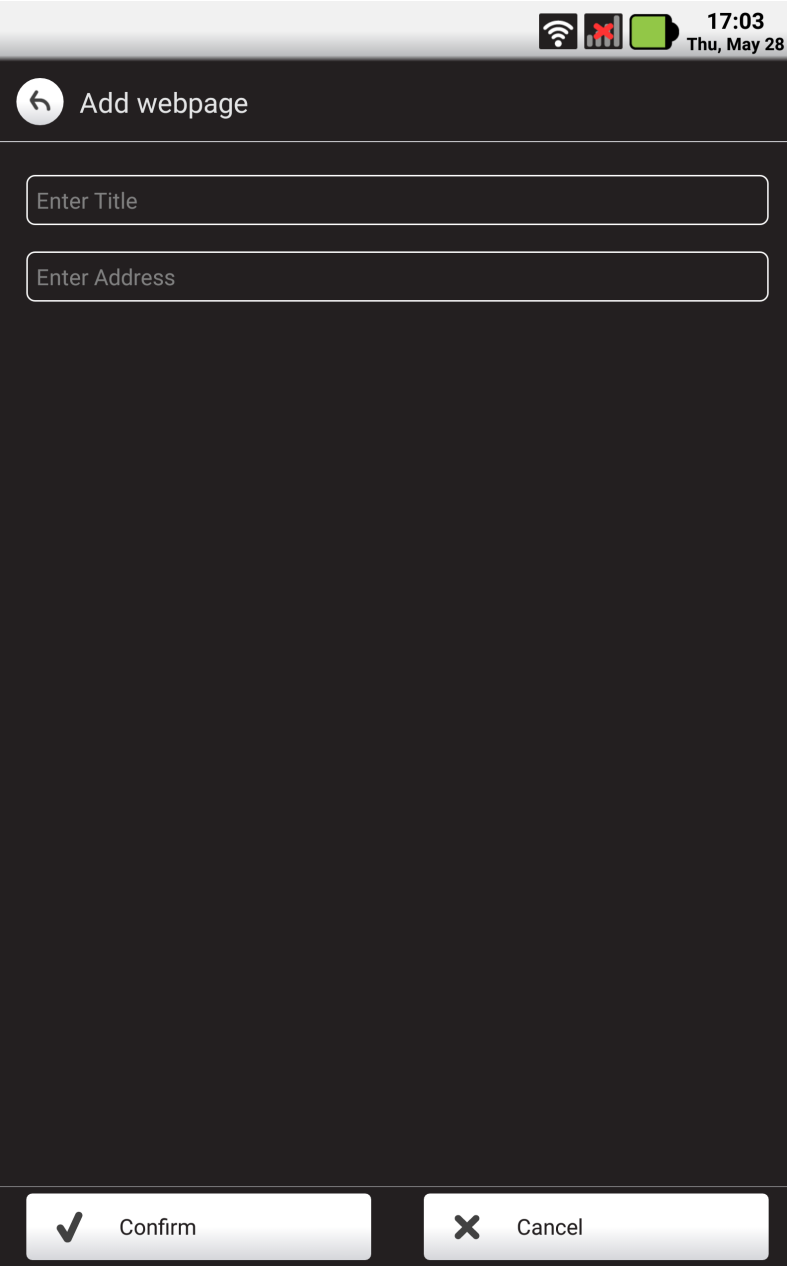
Figure F.7: Application main screen (tablet - EN)

Final prototypes



Figure F.8: Screen that shows the webpages inside a category - in this case, news (tablet - EN)

Final prototypes



The image shows a mobile application interface for adding a webpage. At the top, there is a status bar with icons for Wi-Fi, cellular signal, and battery, along with the time 17:03 and the date Thu, May 28. Below the status bar is a dark header with a back arrow icon and the text "Add webpage". The main area contains two text input fields: "Enter Title" and "Enter Address". At the bottom, there are two buttons: "Confirm" with a checkmark icon and "Cancel" with an 'X' icon.

17:03
Thu, May 28

← Add webpage

Enter Title

Enter Address

✓ Confirm

✕ Cancel

Figure F.9: Screen for adding a webpage to a category (tablet - EN)

Final prototypes

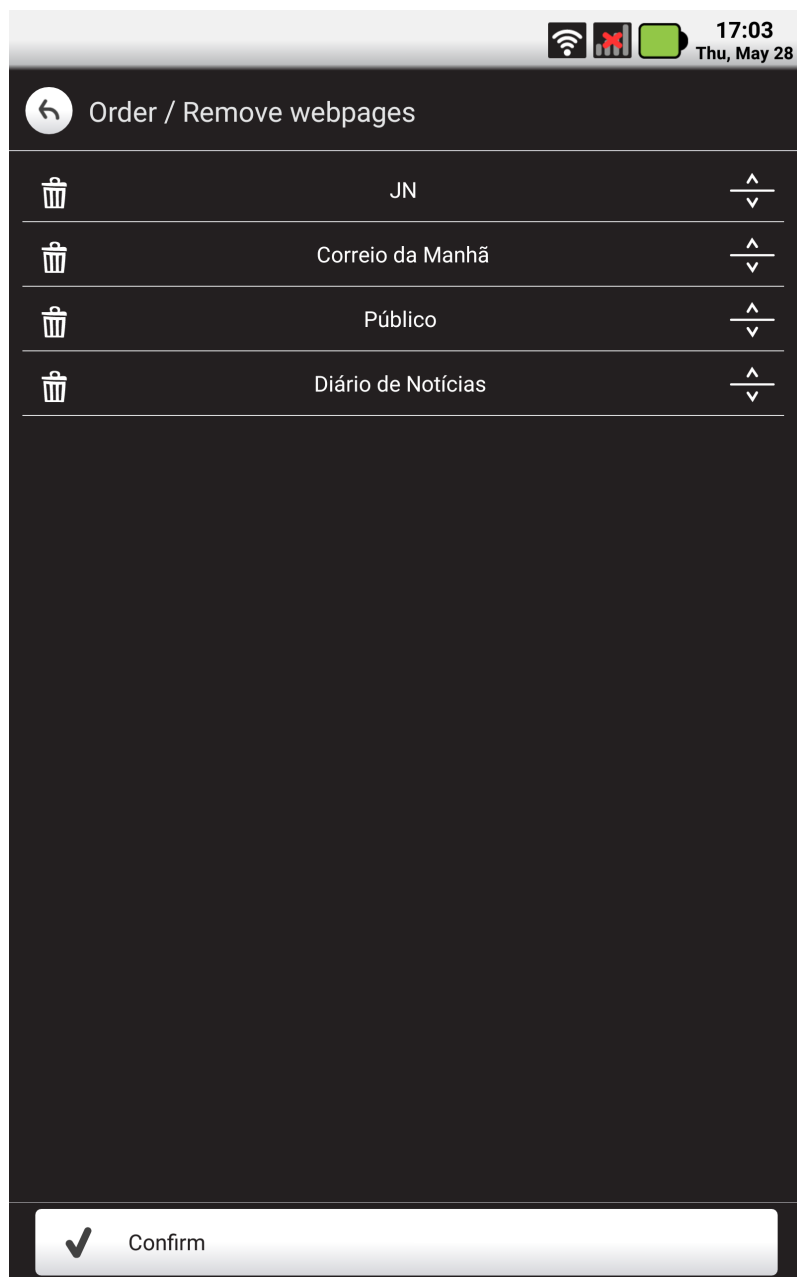


Figure F.10: Screen for ordering or removing a webpage within a category (tablet - EN)

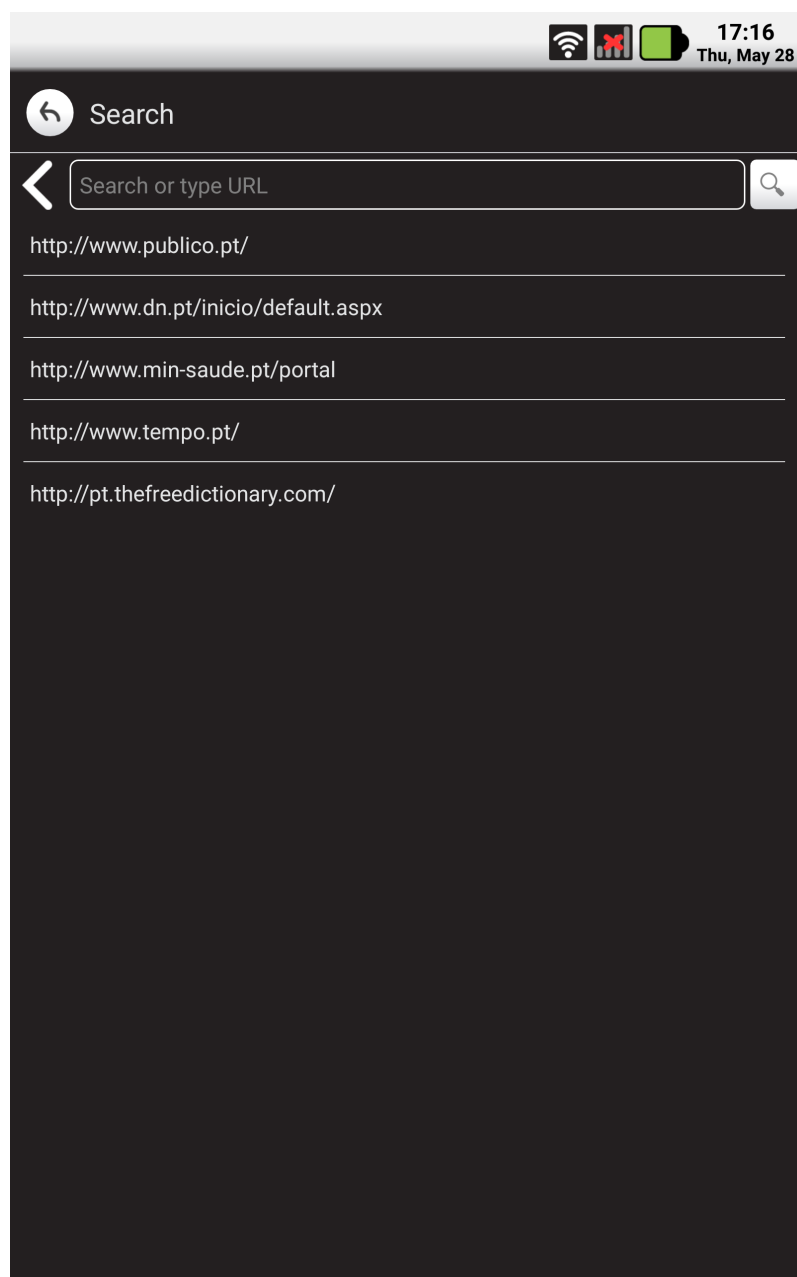


Figure F.11: Screen for searching for information on the Web (tablet - EN)

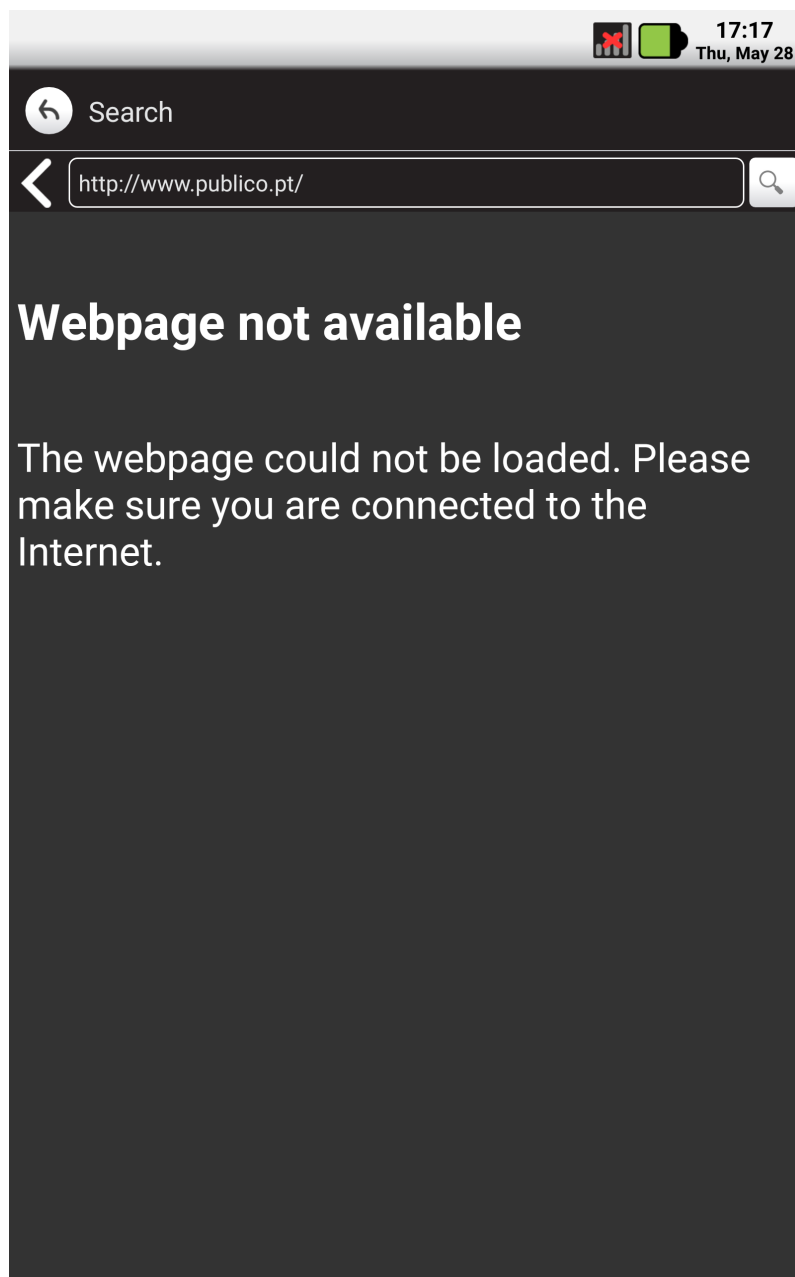


Figure F.12: Custom error page (tablet - EN)

F.3 Application final prototypes for the tablet - Portuguese version

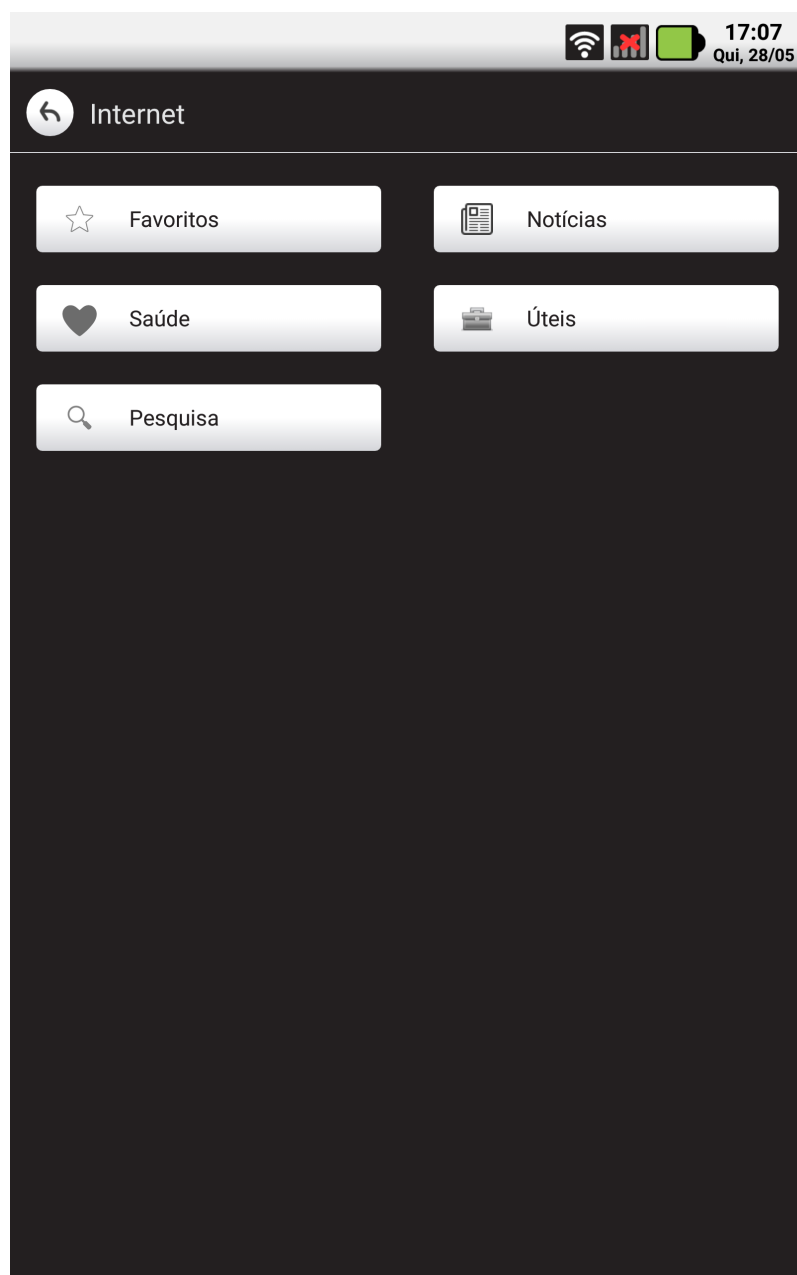
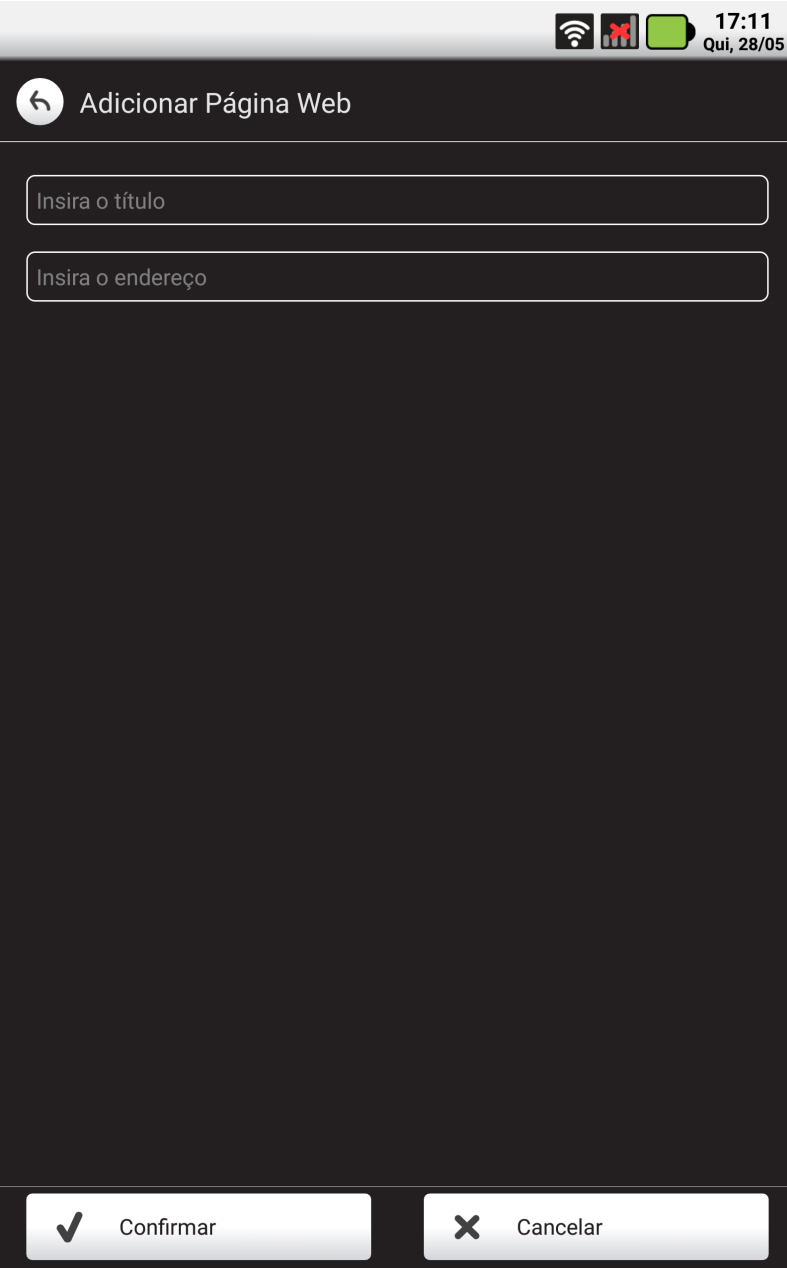


Figure F.13: Application main screen (tablet - PT)

Final prototypes



Figure F.14: Screen that shows the webpages inside a category - in this case, news (tablet - PT)



The image shows a mobile application interface on a tablet. At the top, there is a status bar with icons for Wi-Fi, cellular signal, and battery, along with the time 17:11 and date Qui, 28/05. Below the status bar is a dark header bar with a back arrow icon and the text "Adicionar Página Web". The main area of the screen contains two text input fields. The first field is labeled "Insira o título" and the second field is labeled "Insira o endereço". At the bottom of the screen, there are two buttons: "Confirmar" with a checkmark icon and "Cancelar" with an 'X' icon.

17:11
Qui, 28/05

Adicionar Página Web

Insira o título

Insira o endereço

✓ Confirmar ✕ Cancelar

Figure F.15: Screen for adding a webpage to a category (tablet - PT)

Final prototypes

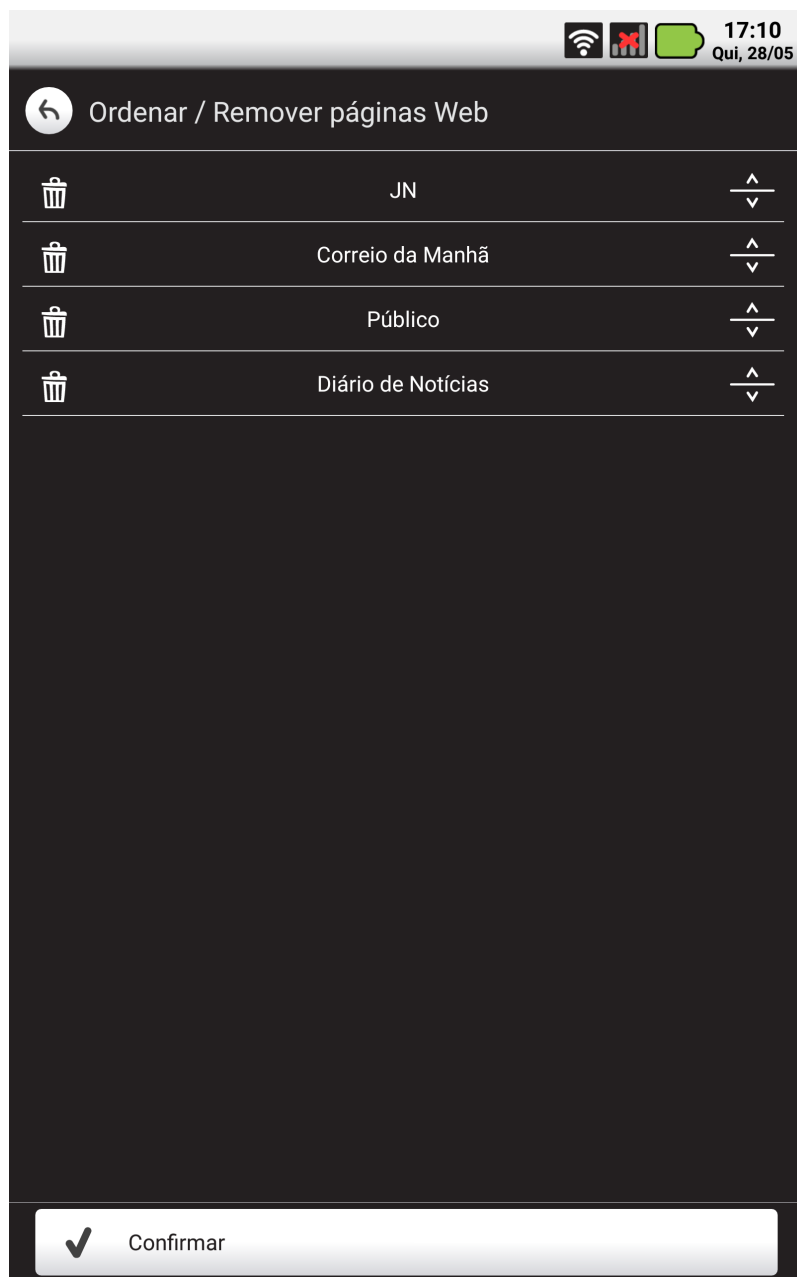


Figure F.16: Screen for ordering or removing a webpage within a category (tablet - PT)

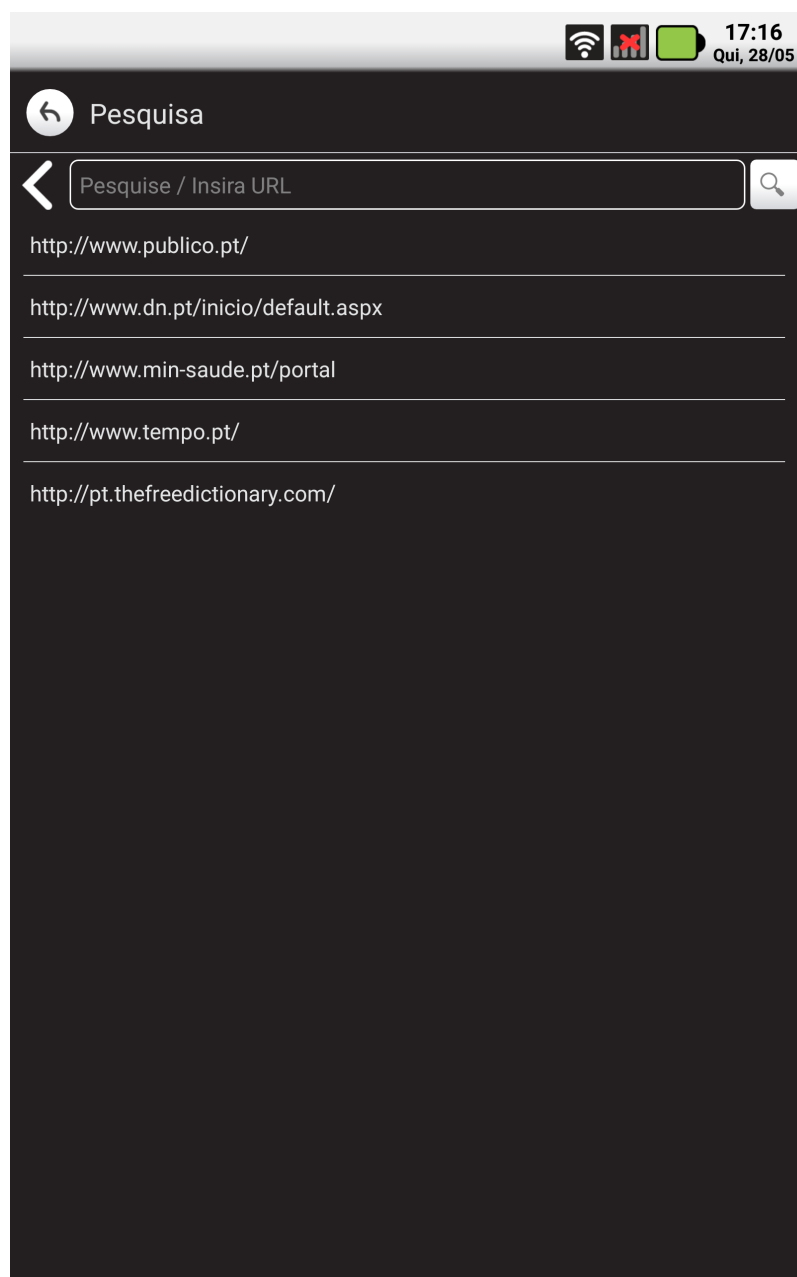


Figure F.17: Screen for searching for information on the Web (tablet - PT)

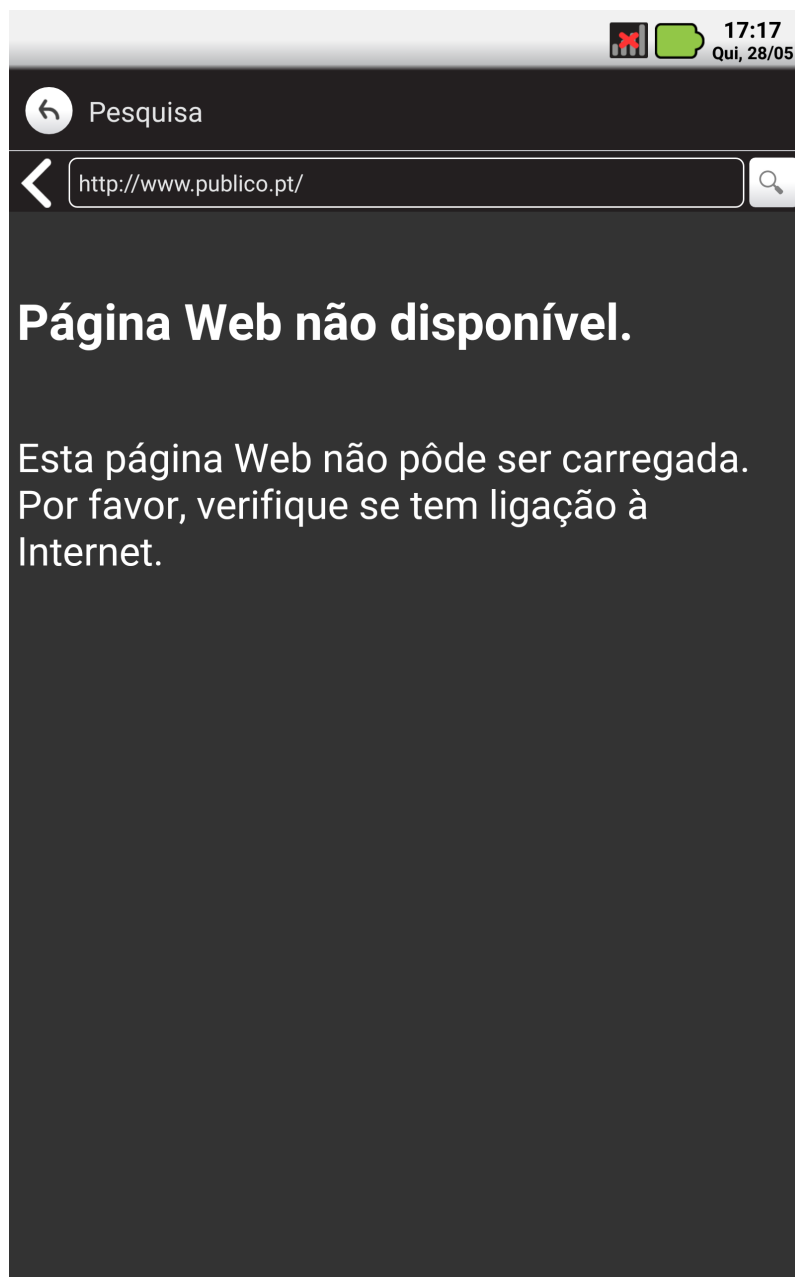


Figure F.18: Custom error page (tablet - PT)

F.4 Dialogs - English version

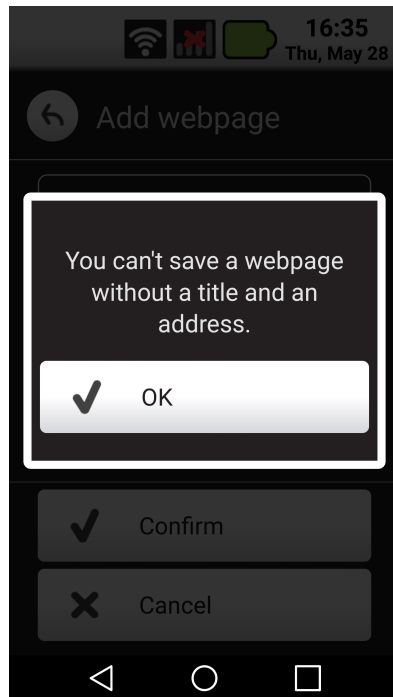


Figure F.19: Dialog informing the user that action cannot be performed

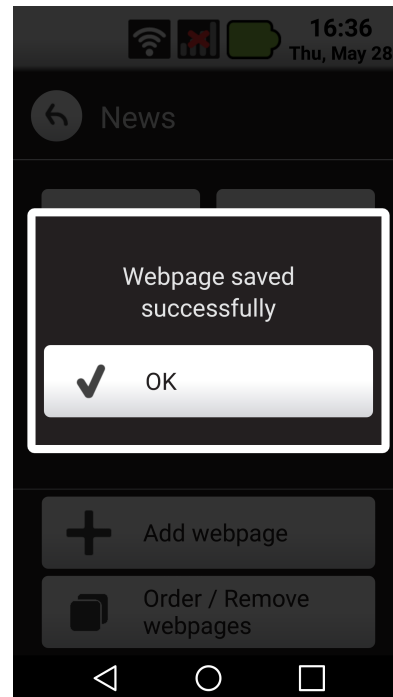


Figure F.20: Dialog informing the user that webpage was successfully saved



Figure F.21: Dialog suggesting an action to the user (PT)

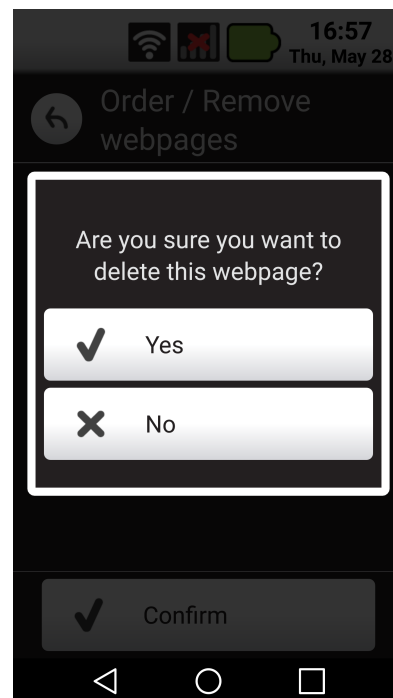


Figure F.22: Dialog asking the user for confirmation to perform an action

F.5 Dialogs - Portuguese version

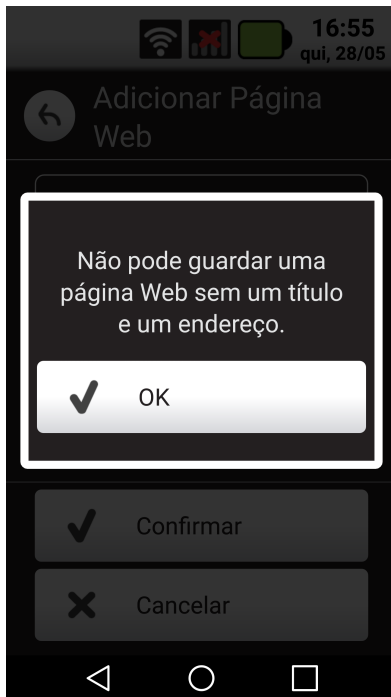


Figure F.23: Dialog informing the user that action cannot be performed (PT)



Figure F.24: Dialog informing the user that webpage was successfully saved (PT)

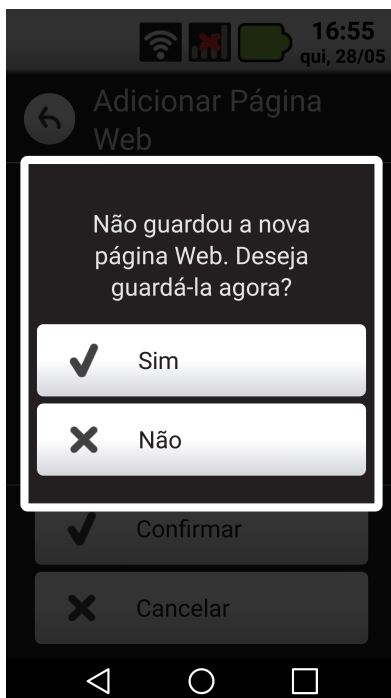


Figure F.25: Dialog suggesting an action to the user (PT)

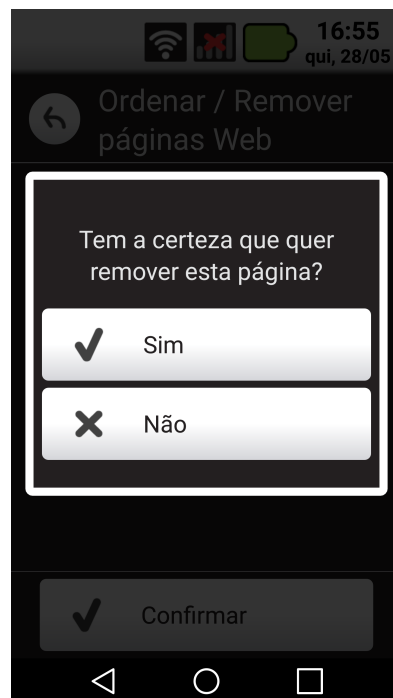


Figure F.26: Dialog asking the user for confirmation to perform an action (PT)

Appendix G

Screenshots of customized webpages

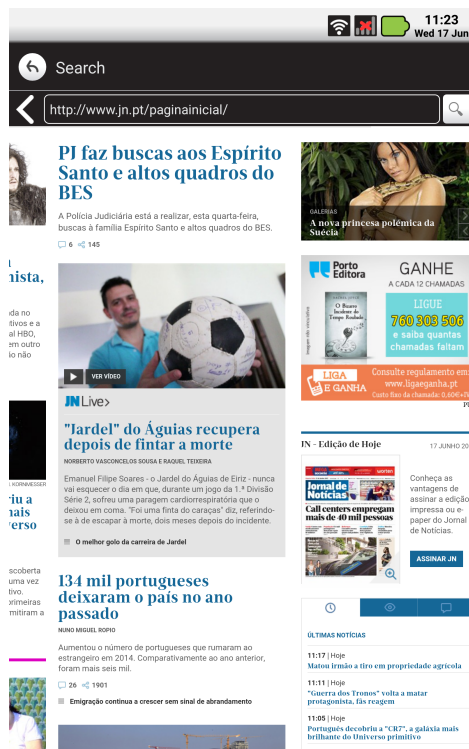


Figure G.1: "Jornal de Notícias" original webpage



Figure G.2: Same webpage, after customization

Screenshots of customized webpages



Figure G.3: "Diário de Notícias" original webpage



Figure G.4: Same webpage, after customization

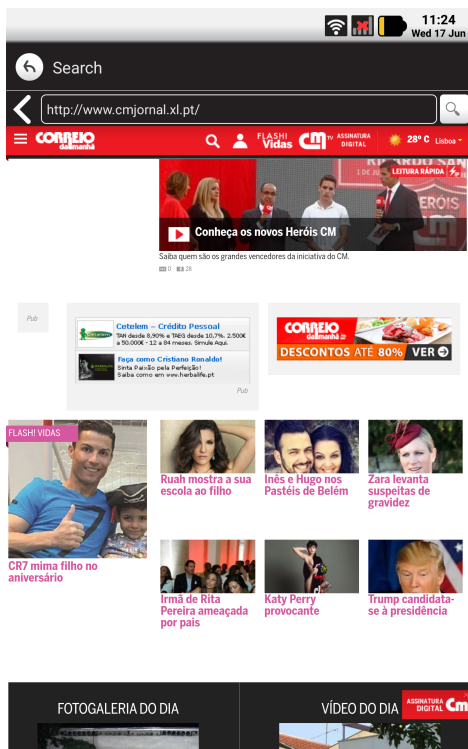


Figure G.5: "Correio da Manhã" original webpage

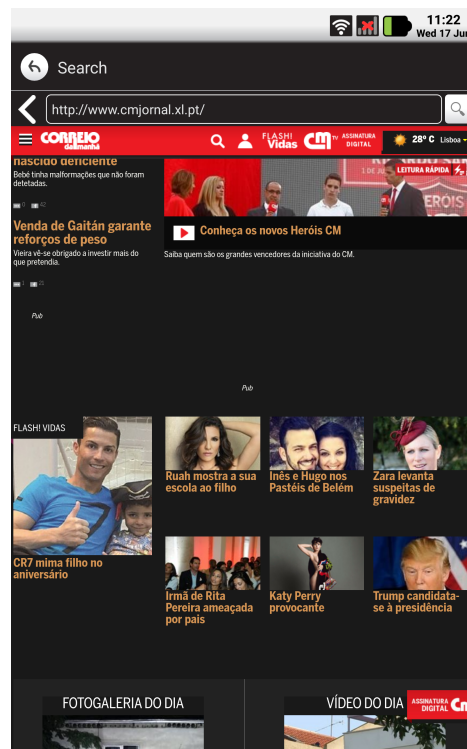


Figure G.6: Same webpage, after customization

Screenshots of customized webpages

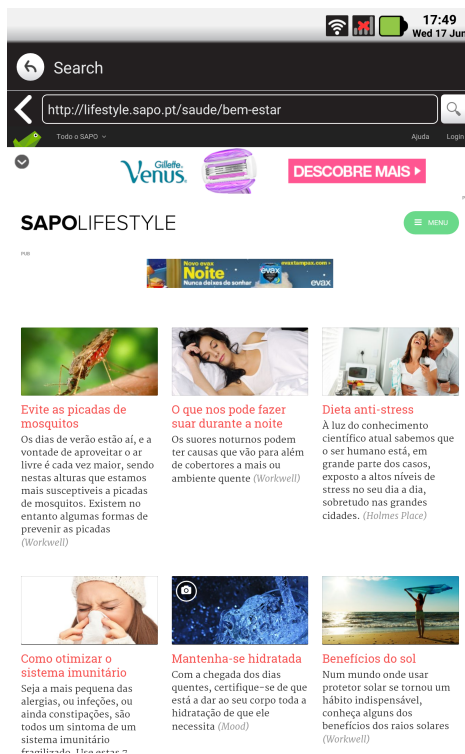


Figure G.7: "SAPO Lifestyle" original webpage



Figure G.8: Same webpage, after customization



Figure G.9: Weather original webpage

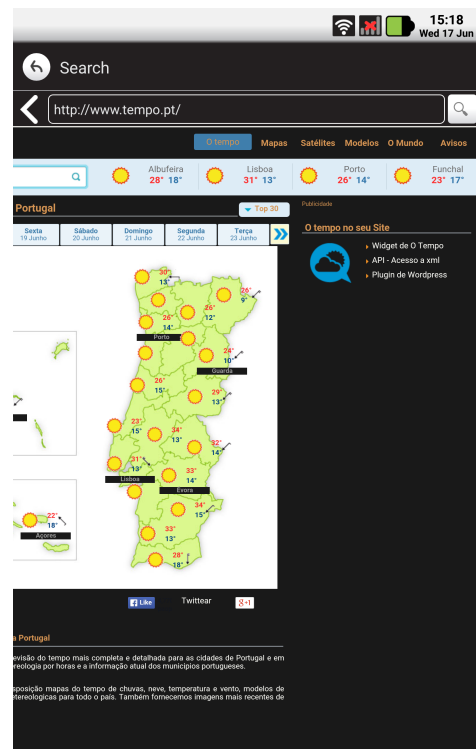


Figure G.10: Same webpage, after customization

Screenshots of customized webpages

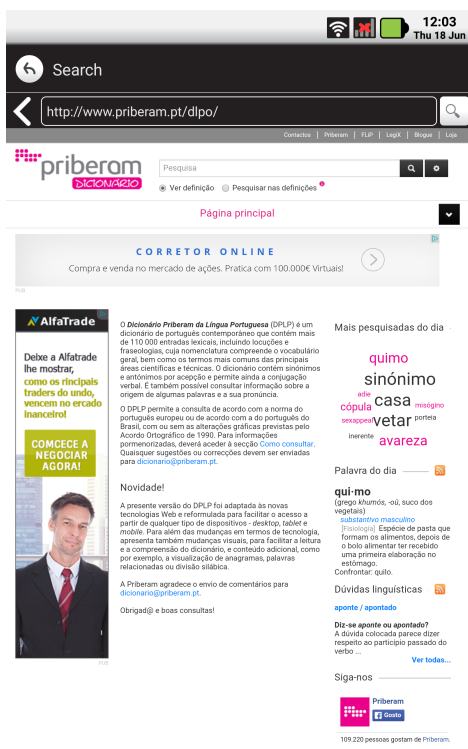


Figure G.11: Priberam dictionary original webpage

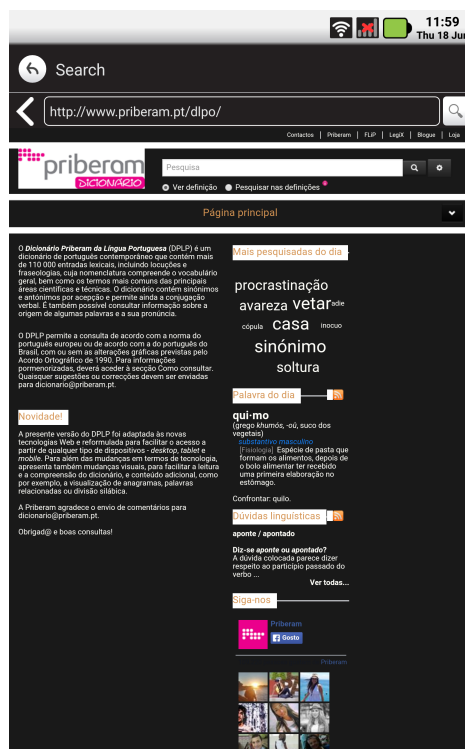


Figure G.12: Same webpage, after customization



Figure G.13: "RFM" original webpage

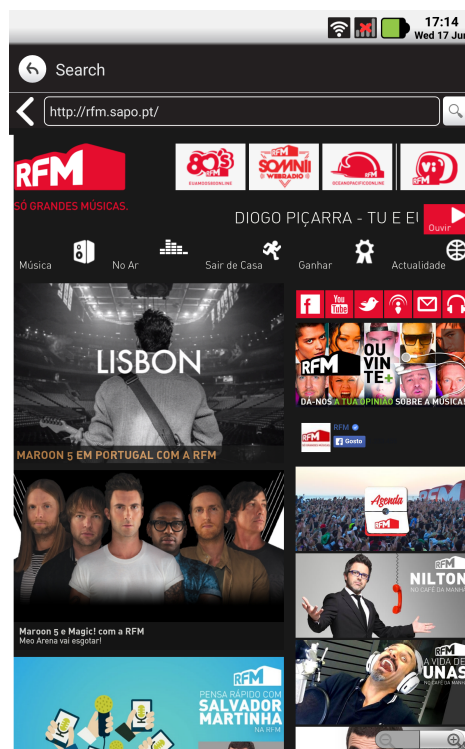


Figure G.14: Same webpage, after customization

Appendix H

Submitted paper - CHITaly 2015

EzNav: A mobile Web browser for the elderly

Ana Santos
Associação Fraunhofer Portugal
Research
Rua Alfredo Allen, 455/461
4200-135 Porto, Portugal
ana.santos@fraunhofer.pt

Renato Oliveira
Associação Fraunhofer Portugal
Research
Rua Alfredo Allen, 455/461
4200-135 Porto, Portugal
renato.oliveira@fraunhofer.pt

Miguel Pimenta Monteiro
Dep. Engenharia Informática,
Faculdade de Engenharia,
Universidade do Porto
Rua Roberto Frias, s/n 4200-465
Porto, Portugal
apm@fe.up.pt

ABSTRACT

Ageing population is increasing around the world and a similar trend is being observed in the population of Internet users. In fact, some studies revealed that people aged 60 years and over constitute the fastest growing group of information seekers on the World Wide Web.

However, inadequate interface designs of existing technology tools and apps constitute a barrier to elders' digital inclusion. Besides, most older adults suffer from a decline in their visual, motor and cognitive skills that may hamper Web interaction.

This paper presents EzNav, a mobile application that consists of a Web browser for older adults, focusing on their needs. For that, several studies and analysis on Web interaction were held, in order to find possible modifications and improvements regarding senior user interaction with current technologies.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: User-centered design

General Terms

Design, Human Factors

Keywords

Human-Computer Interaction, Older adults, Internet, Browser, Mobile devices

1. INTRODUCTION

Ageing population is increasing around the world, and will continue to do so for the next decades: it is expected that by 2025 there will be around 1.2 billion over-60 people, reaching approximately 2 billion by 2050. Consequently, the number of older adults that use the Web to enhance their independent participation in society will increase [6].

In fact, people aged 60 years and over constitute the fastest growing group of information seekers on the World Wide Web [3].

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However, inadequate information layouts and interface designs of existing technology tools and apps constitute a barrier to elders' digital inclusion. So, it is important to combat this, by finding an effective way to involve the elderly in the development [1].

This paper presents EzNav, an Android mobile application that consists of a Web browser for older adults, focusing on their needs. This application is senior-oriented, since it considers not only graphical user interface (GUI) aspects (like using fewer, bigger buttons) but also Web engine aspects (removing ads, increasing font size, enlarging images). Several studies and analysis on Web interaction were held, in order to find possible modifications and improvements regarding senior user interaction with current technologies.

The remainder of this paper is organized as follows: section 2 describes the context and problems that EzNav addresses; section 3 details the conception and implementation behind the mobile application; section 4 expounds the preliminary results of interviews and usability testing; and section 5 makes a brief conclusion and outlines aspects for future work.

2. INTERNET USAGE BY OLDER ADULTS

According to some authors [10], the regular use of the Internet may help to reduce isolation, loneliness [8] and depression rates in older adults, especially because it promotes interaction and social life, overcoming limiting barriers such as physical disabilities [5]. That way, the Internet can help seniors to maintain their independence, thus improving their quality of life. This is probably one of the reasons why Internet use by older adults has increased in the past few years [7].

In fact, the most frequent reason for seniors to use the Internet is to keep in touch with family, relatives and friends. Accessing news and research on health topics is also frequent, which makes search engines some of the most favourite websites [7].

However, as people get older, some difficulties arise, such as vision, cognitive and motor impairments, that may be an obstacle for Web interaction [2][7].

Besides physical impairments, there are some behavioural characteristics that prevent seniors to take full advantage of Web functionalities, such as increased cautiousness and low confidence on their ability to use technologies, including the Web, due to the fact that some older people never used this (or any other) kind of technology.

Introducing the technology in a highly interactive and understandable manner may positively influence the receptivity of older adults toward technological devices [4].

3. DESIGNING A MOBILE WEB BROWSER FOR ELDERLY PEOPLE

In order to validate this solution and get feedback from users, both low-fidelity prototypes (using the Wizard of Oz technique) and high-fidelity prototypes were developed, whose test population is a group of elders, at a day care centre. This was important to create a fast-paced cycle of continuous development and testing, thus increasing the received feedback and, consequently, the overall quality of the system. Given these premises, the development of this project followed a user-centred design (UCD), a methodology that puts the user at the centre of the design process.

Interviews were made to understand the seniors' mobile device and Internet usage patterns, as well as finding out if there were any functional impairments that could compromise Web interaction. Some terminology tests were also made, so the most understandable name for each option could be used. Card sorting was also used to select the most appropriate icons for each option. Finally, the seniors were asked to perform some tasks, in order to test the application's usability. The results of these tests can be found in section 4.

The resultant application was implemented for the Android mobile operating system. Based on Linux, Android is a low-cost, customizable and lightweight open-source mobile operating system widely used by almost every mobile phone manufacturer, leading the smartphone market with 283 million units shipped, totalling 84% of the share (data from jul-sep 2014) [9].

3.1 Application's design

The application design aimed at being simplistic and easy to learn and understand, especially because most elderly people had little to no experience with smartphones and tablets. Central to this ideology was the need for simple screens, including only essential functionality for a mobile Web browser and following a set of layout rules to ensure consistency across the system, with well-defined conventions for the position of information and buttons.

With these needs in mind, every application screen is divided into three main components: at the top, there is a header with a concise and descriptive title so the user can know where in the application he/she is or what he/she can see or do in that screen (e.g. "Search", "Add webpage"); in the middle of the screen is the main content (e.g. a webpage or a list of webpages); at the bottom are the buttons that represent the possible actions the user can perform (e.g. "Add webpage", "Order/Remove webpages"). In addition, every screen includes a customized and senior-friendly status bar. Besides these rules, and in order to provide high contrast (negative polarity) and improve legibility, light text colour is used on dark background. Also, big buttons and large font sizes are favoured, so users have no difficulties reading or tapping the options. Figure 1 shows the application of these conventions.

3.2 Webpage customization

Even though designing a senior-oriented application theoretically improves Web interaction for older people, there is a need for customizing webpage's presentation for these users. This happens because, although there are many accessibility guidelines for designing Web applications, many websites do not adhere to them, or if they do, some assume that users are familiar with the technology. Besides, what is beneficent for one user might be

counter-productive for another [4]. Thus, Web interaction for elder users (and, in fact, other types of users) would be improved if webpage presentation was also personalized to fit an individual's need.

Several studies have been performed on the ageing-related changes and their impact on Web interaction, and there are already many guidelines to fight these impairments [4], namely: using 12- or 14-point font size, maximizing information/background contrast in critical areas, presenting important information as close to the centre of the screen as possible, presenting text in small blocks and making an effective use of white spaces, using negative polarity, avoiding ads as well as moving, blinking and flashing objects.

Considering these guidelines, EzNav aims at improving Web browsing experience, by simplifying webpages' content and adapting the browser to fit user needs. The customizations made at the moment consist of implementing negative polarity in every webpage, by adapting the webpage Cascading Style Sheets (CSS), as well as removing ads (Figure 2), which is achieved by blocking calls to common publicity sources. This is still being improved. Also, the most frequently webpages visited by users are recorded in a list, allowing the application to adapt to each user's habits, such as when visiting the "Search" screen (Figure 3).



Figure 1. Screen that displays the webpages within a given category ("News" in this case)



Figure 2. Negative polarity and ads removal (at the centre of the webpage)

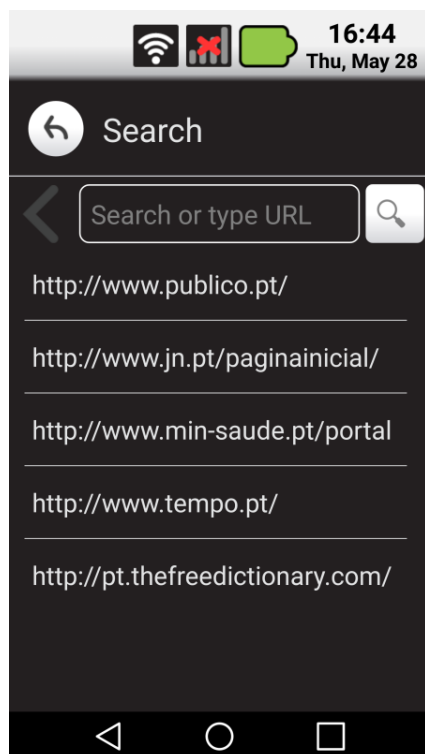


Figure 3. "Search" screen, showing the list of most visited webpages

4. INITIAL RESULTS AND ANALYSIS

Usability tests were performed early in the design phase, on two day care centres, through the use of prototypes on paper. A Wizard of Oz technique was used, with a person simulating the behaviour of the application, by changing screens (papers) or adding some elements to the screen.

In addition, interviews were made to 10 seniors, in order to collect some relevant data, like Internet and touchscreen devices usage and ageing-related problems that may hamper Web interaction. Respondents ages ranged from 69 to 88 years old (Figure 4 displays age distribution) and all of them wore glasses. As can be seen in Figure 5, experience with touchscreen devices like smartphones and tablets is reduced. As for Web usage patterns (Figure 6), the most frequent reasons for most of the elderly to not usually surf the Web were not owning a computer and being afraid of doing something wrong or causing some damage.

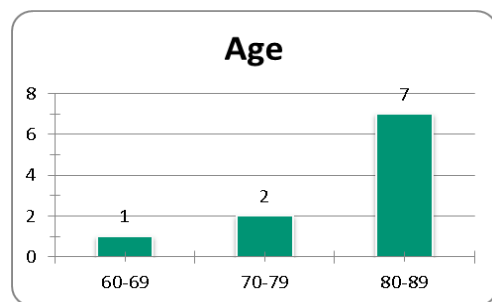


Figure 4. Test participants' age distribution

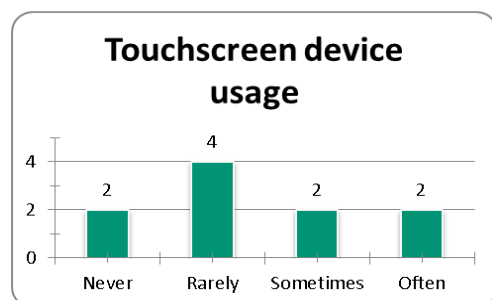


Figure 5. Test participants' touchscreen device usage

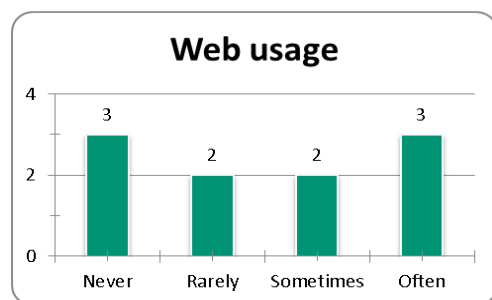


Figure 6. Test participants' web usage

Regarding the usability tests, 6 of the 10 seniors were asked to perform 5 tasks, which were completed successfully and with no effort, which indicated that the design was on the right track. Thus,

and since there were only some minor changes to be made, the second round of usability testing was left for later in the development phase, using high-fidelity prototypes.

In this second round of tests, the participants were asked to perform 9 tasks. As can be seen in Figure 7, the average number of deviations from the expected number of steps to complete the tasks was very small, which suggests that the application is, indeed, senior-friendly.

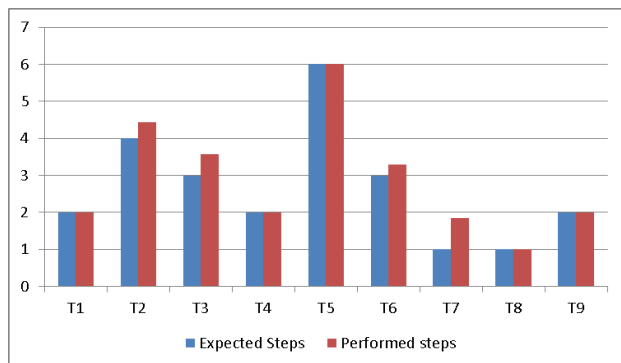


Figure 7. Comparison between the number of expected steps to complete each task and the number of performed steps by participants

After completing the tasks, participants were asked to answer a small questionnaire, in order to evaluate their experience and satisfaction while using the application. Using a scale from 1 ("strongly disagree") to 5 ("strongly agree"), they answered the following questions:

1. I found the application easy to use.
2. I felt confident while using the application.
3. I found it easy to learn how to use the application.
4. I would like to use this application again.

Figure 8 displays the results obtained.

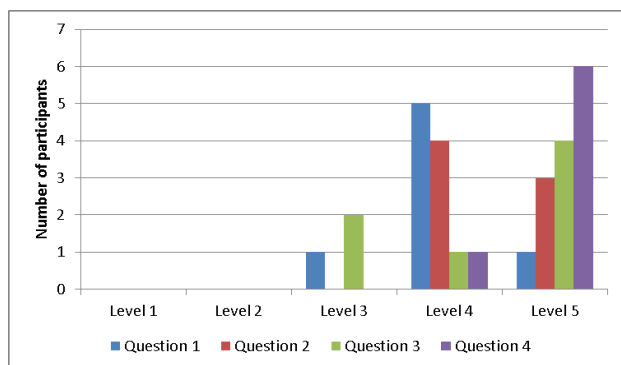


Figure 8. Questionnaires results

The results from the questionnaire are promising, since they showed that participants, in general, had a nice experience while using the application and would like to use it again.

5. CONCLUSION AND FUTURE WORK

Older adults are subject to feelings of loneliness resulting from isolation. The Web can have a crucial role in fighting this, by

allowing these people to stay in touch with their family and friends, and also as a form of learning and entertainment. EzNav was designed to be as intuitive as possible, bypassing common impairments and limitations that come with the ageing process.

Initial results from the usability testing proved promising, and the UCD approach will allow the application to continue evolving while being tailored to the senior user population. Further testing is already underway. Future work will be focused in improving the webpages customization. Another aspect that is yet to be explored is the implementation of better machine learning algorithms, so the browser can self-adapt to each individual's needs.

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